HUMAN BIOLOGY
a record of research

MAY, 1958

VOL. 30 No. 2

GROWTH IN HEIGHT OF TEN SIBLINGS

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INTRODUCTION

THE English family whose growth is here described consisted of 5 brothers and 5 sisters who were born between 1864 and 1884. Their father measured their height at each birthday, from the first onwards, by standing them with their backs to a board, without shoes, and placing a ruler on their heads, parallel to the floor. The height was then marked on the board at the appropriate level, each child having a separate column. The board also carries measurements of the son of the eldest brother at ages from three to 20 years. These measurements are the material for the present study and are presented for two reasons: first, that longitudinal growth studies, even of one dimension, on so many siblings, are unusual and afford material for the study of genetic variability and of sex differences in growth; and secondly, that such observations are rare in the period under consideration, and are of interest in relation to secular changes in rate of growth.

The family was a well-to-do upper middle class one, and the environment in which the children grew up was as good as was available at that time. All the 5 boys went to English public (private) schools, while the girls were educated at home.

Technique of Measurement

Measurements of the recorded heights were made with a steel rule which was hooked round the bottom of the board by a flange level with the zero mark. They were taken to the nearest tenth of a centimeter.

The 5 brothers are hereafter called M1-5 by order of birth and the 5 sisters similarly F1-5. The son of M1 is designated S1. The birth order of the family was as follows: F1, M1, M2, F2, F3, M3, F4, F5, M4, M5.

OBSERVATIONS

Table 1 gives the recorded heights of the family at their various ages. Certain measurements are starred; these were taken three or four months after the birthday concerned (for example, the age marked on the board is $5\frac{1}{4}$ or $5\frac{1}{3}$) and have been corrected by reducing the increment for the preceding year by the appropriate fraction, to give a closer approximation to the correct value.

Figure 1 shows the mean height of the 5 brothers (continuous line) and 5 sisters (dotted line) plotted against age. Up to 9 years the yearly gain in height was similar in both sexes. The brothers were about 2.5 cm taller at any given age (the mean difference in height between the two sexes from one to 9 was 2.59 cm). At 9, growth of the sisters was slowed for a year, and then the adolescent spurt of growth took place. By 17, growth was finishing. The brothers continued to grow at a steady rate from 9 to 11 and then like their sisters showed a temporary slowing of growth followed by the adolescent spurt. At 19, slight growth was still taking place.

The speed of growth during the adolescent period was similar in both sexes, and the growth curves can almost be superimposed if the difference of two years in time of onset of adolescence is eliminated. The only difference was that the male spurt started slightly more slowly and reached a greater maximum velocity than the female spurt; this is shown in figure 2 which shows the mean yearly increments of stature of the two sexes superimposed (with the two years difference in onset of adolescence eliminated). Table 2 gives the total mean increment in height at each year after the age of 9 (females) and 11 (males).

The increases are very similar, and after 7 years the difference in total increment is only 1.2 cm.

The difference in mean adult height between the sexes is not known exactly, but was probably about 15 cm. Ten cm of this were due to the

TABLE 1

Height in centimeters at ages 1-24 years

AGE (years)	M1	M2	M3	M4	M5	F1	F2	F3	F4	F5	S1	MEAN M1-5	MEAN F1-5
1	73.4	73.4	76.7	72.4	76.5	71.9	70.9	73.7	75.7	72.6		74.5	73.0
2	84.3	85.1	86.7	85.1	86.7	81.0	82.3	81.8	85.8	83.1		85.6	82.8
3	92.9	92.2	96.0	94.5	94.0 *	89.7	90.7	91.9	93.4	91.9	95.0	93.9	91.5
4	98.0	101.6	102.6	101.1	102.1	96.8	96.8	98.0	101.9	99.6	105.4	101.1	98.6
5	108.0	109.0	110.5	108.2 *	108.7	103.1	103.6	105.4	108.2	105.4 *		108.9	105.1
6	113.1	113.8	116.8	114.8 *	114.8	108.7	111.2	111.5	117.1	112.4	119.9	114.7	112.2
7	118.8	120.9	121.2	123.4 *	119.7	115.1	116.8	117.8	121.7 *	116.3	126.3	120.8	117.5
8	123.7	125.3	128.0	127.8	124.8	120.7	120.4	121.4	128.5	119.9	132.6	125.9	122.2
9	128.3	131.3	133.1	132.4	129.5 *	126.3	128.8	125.5	132.6	125.8	136.4	130.9	127.8
10	133.6	137.2	137.5	138.5	134.1	128.8	131.8	131.0	136.6	130.3	141.0	136.2	131.7
11	138.7	142.0	141.5	141.2	138.5	135.1	136.4	135.1	140.7	134.9	145.1	140.4	136.4
12	143.5	145.3	145.6	144.8	141.5	142.7	140.7	139.2	146.8	140.7	151.9	144.1	142.0
13	147.1	150.9	150.4 *	148.1	145.6	148.1	146.6	144.2	153.7	148.8	157.5	148.4	148.3
14	154.7	156.9	155.2	153.9	151.2	153.7	153.4	151.9	159.0	154.7	165.1	154.4	154.5
15	163.9	165.4	160.8	160.5	158.3	156.2	158.0	154.7	161.8	157.5 *	169.9	161.8	157.6
16	169.6	169.6	170.5	165.9	165.6		161.0	156.7	162.9	159.3	172.7	168.2	(160.0)
17	172.0		176.3	167.9	170.2	157.2		160.5	164.4		174.7	(171.6)	(160.7)
18	173.5	173.5	179.3	169.6	172.2		164.9		165.1		176.6	173.6	
19	175.0	174.5	179.8									(176.4)	
20				170.7							177.1		
22					173.5								
24				171.7									

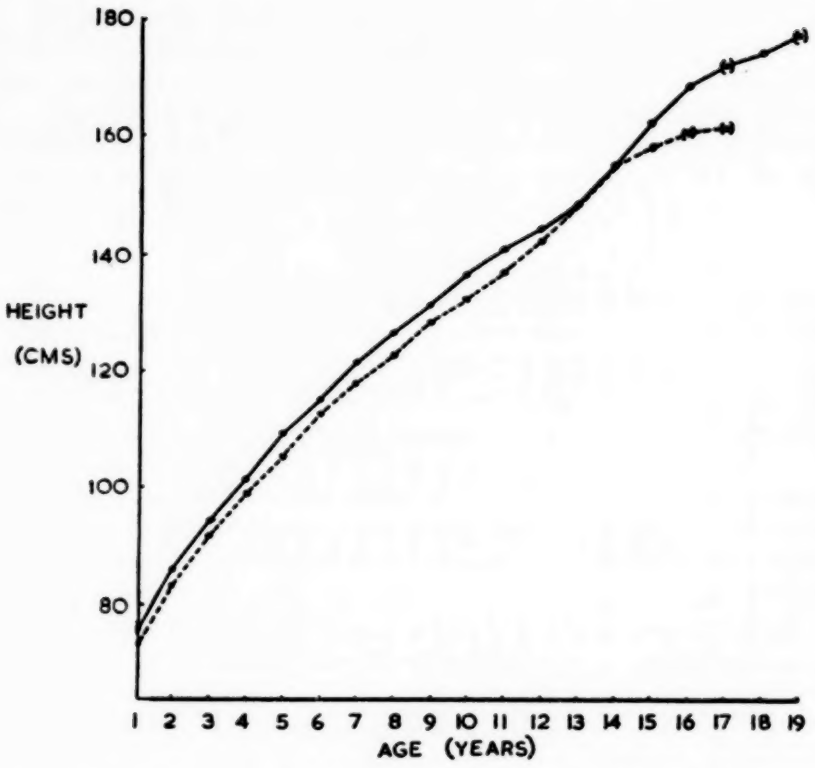

FIG. 1. MEAN GROWTH CURVES FOR MALES (CONTINUOUS LINE) AND FEMALES (DOTTED LINE). THE POINTS IN BRACKETS ARE THOSE FOR WHICH MEASUREMENTS OF ALL 5 BROTHERS OR SISTERS WERE NOT AVAILABLE.

TABLE 2

Total increase in height in cm at each year over 9 (females) and 11 (males)

YEAR	1st	2nd	3rd	4th	5th	6th	7th
Increase (females)	3.9	8.6	14.2	20.5	26.7	29.8	32.0
Increase (males)	3.7	8.0	14.0	21.4	27.8	31.2	33.2

more prolonged growth period (from the age of 9 to 11) of the males, about 2.5 cm were due to greater size of the male before adolescence and about 2.5 cm to greater growth of the males during and after adolescence.

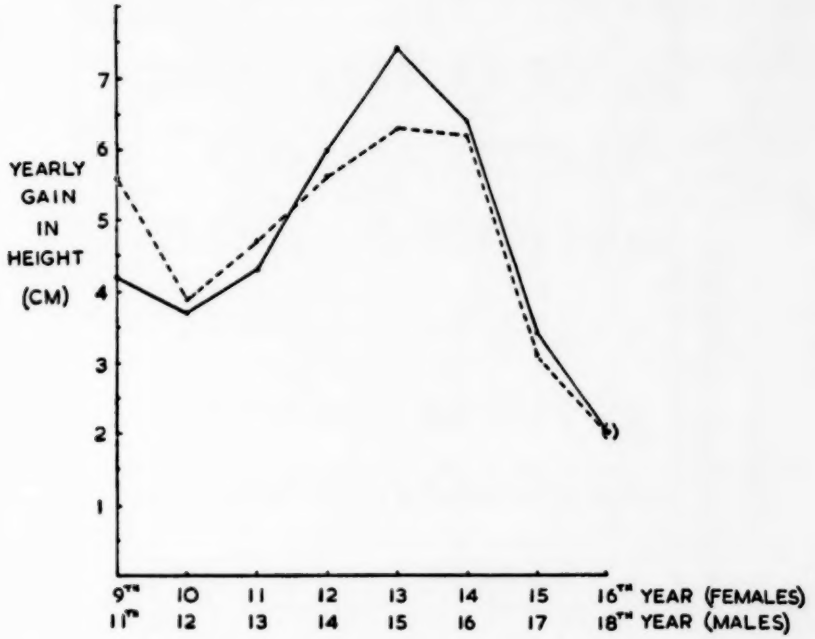

FIG. 2. YEARLY INCREMENTS OF HEIGHT DURING THE ADOLESCENT PERIOD OF MALES (CONTINUOUS LINE) AND FEMALES (DOTTED LINE) SUPERIMPOSED BY ELIMINATING THE DIFFERENCE OF TWO YEARS IN AGE OF ONSET OF ADOLESCENCE.

Evidence from the curves of mean growth for a juvenile (mid-growth) spurt is indecisive; there is a suggestion of a slight temporary quickening of growth at 7-8 years.

Table 3 gives the yearly increments of height of each of the 10 siblings. Males and females will be considered separately. Up to 11 years there was little difference in size between the brothers. The mean range of height was 4.0 cm (1.5-5.4 cm), whereas after 11 was 6.4 cm (4.0-9.6 cm) owing to the variations in time of onset of adolescence. M3 tended to be taller than his brothers at all ages.

There is a suggestion that greater height before adolescence (M3 and M5) was associated with a late onset of adolescence.

TABLE 3

Yearly increments in height, in centimeters

YEAR	M1	M2	M3	M4	M5	F1	F2	F3	F4	F5	S1	MEAN M1-5	MEAN F1-5
2nd	10.9	11.7	10.0	12.7	10.2	9.1	11.4	8.1	10.1	10.5		11.1	9.8
3rd	8.6	7.1	9.3	9.4	7.3	8.7	8.4	10.1	7.6	8.8		8.3	8.7
4th	5.1	9.4	6.6	6.6	8.1	7.1	6.1	6.1	8.5	7.7	10.4	7.2	7.1
5th	10.0	7.4	7.9	7.1	6.6	6.3	6.8	7.4	6.3	5.8	} 14.5	7.8	6.5
6th	5.1	4.8	6.3	6.6	6.1	5.6	7.6	6.1	8.9	7.0		5.8	7.1
7th	5.7	7.1	4.4	8.6	4.9	6.4	5.6	6.3	4.6	3.9	6.4	6.1	5.3
8th	4.9	4.4	6.8	4.4	5.1	5.6	3.6	3.6	6.8	3.6	6.3	5.1	4.7
9th	4.6	6.0	5.1	4.6	4.7	5.6	8.4	4.1	4.1	5.9	3.8	5.0	5.6
10th	5.3	5.9	4.4	6.1	4.6	2.5	3.0	5.5	4.0	4.5	4.6	5.3	3.9
11th	5.1	4.8	4.0	2.7	4.4	6.3	4.6	4.1	4.1	4.6	4.1	4.2	4.7
12th	4.8	3.3	4.1	3.6	3.0	7.6	4.3	4.1	6.1	5.8	6.8	3.7	5.6
13th	3.6	5.6	4.8	3.3	4.1	5.4	5.9	5.0	6.9	8.1	5.6	4.3	6.3
14th	7.6	6.0	4.8	5.8	5.6	5.6	6.8	7.7	5.3	5.9	7.6	6.0	6.2
15th	9.2	8.5	5.6	6.6	7.1	2.5	4.6	2.8	2.8	2.8	4.8	7.4	3.1
16th	5.7	4.2	9.7	5.4	7.3	} 1.0	3.0	2.0	1.1	1.8	2.8	6.4	(2.0)
17th	2.4	} 3.9	5.8	2.0	4.6		} 3.9	3.8	1.5		2.0	3.4	
18th	1.5		3.0	1.7	2.0				0.7		1.9	(2.0)	
19th	1.5	1.0	0.5	} 1.1							} 0.5		
20th													

Between one and 9 years the mean height range was much greater for the females than for the males (7.1 cm). This was largely due to F4, who after the age of 5 was consistently much larger than her sisters and to F1 who was always rather small.

TABLE 4

Years of commencement and of peak velocity of the adolescent growth spurt, and increment of height in the year of peak velocity

BROTHER	YEAR OF COMMENCEMENT	YEAR OF MAXIMUM GROWTH	INCREMENT (CM) IN YEAR OF MAXIMUM GROWTH
M1	14th	15th	9.2
M2	14th	15th	8.5
M3	15th	16th	9.7
M4	14th	15th	6.6
M5	14th	15th-16th	7.3

TABLE 5

Years of commencement and of peak velocity of the adolescent growth spurt, and increment of height in the year of peak velocity

SISTER	YEAR OF COMMENCEMENT	YEAR OF MAXIMUM GROWTH	INCREMENT (CM) IN YEAR OF MAXIMUM GROWTH
F1	11th	12th	7.6
F2	13th	14th	6.8
F3	13th	14th	7.7
F4	12th	13th	6.9
F5	12th	13th	8.1

The time of onset of the adolescent spurt varied by two years in the sisters, but the age of peak growth did not seem to be correlated with size before adolescence as it was in the brothers.

Comparison of the growth curves of F2 and F4 at adolescence is striking. Although there was a difference of a year in time of onset of adolescence, if the two curves are superimposed so that the peak velocities of growth coincide (see figure 3) they appear almost identical in form. Clearly the rate of growth at adolescence was the same for both sisters, although the age of onset differed by a whole year.

In the males the probable order of adult height was as follows: M3,

M1, M2, M5, M4. There is no correlation between time of onset of adolescence and adult size, but there may be a correlation between maximum velocity of growth (order M3, M1, M2, M5, M4) and adult height.

In the females the probable order of adult height was as follows: F4, F2, F5, F3, F1. Again there is no correlation between time of onset of adolescence and adult height, nor is there here a relationship between maximum velocity of growth and adult height.

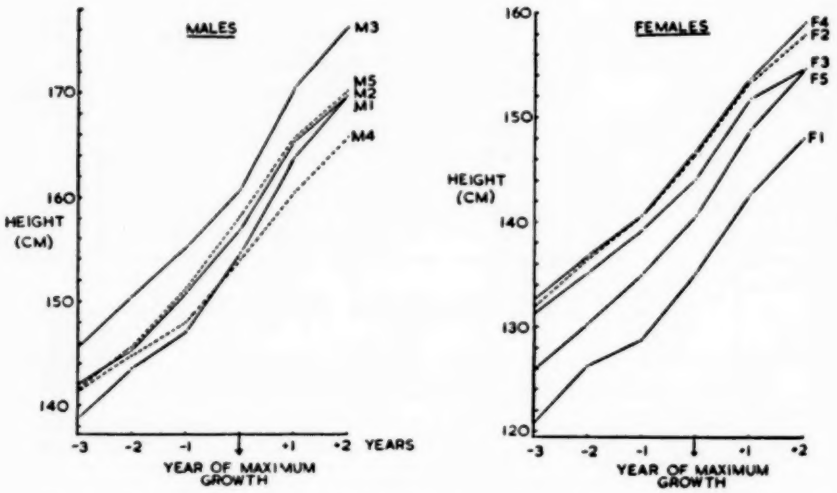

FIG. 3. GROWTH CURVES OF THE 5 BROTHERS (LEFT) AND 5 SISTERS (RIGHT) SUPERIMPOSED BY MAKING THE AGE AT WHICH MAXIMUM GROWTH TOOK PLACE THE SAME FOR ALL, REGARDLESS OF ACTUAL AGE. THERE IS LITTLE CHANGE IN ORDER OF HEIGHT DURING ADOLESCENCE.

S1, the son of M1, was born in 1925, nearly 60 years after his father. His height at ages 3-20 is shown in table 1 and the yearly increments in table 3. The mother's family was of a similar average stature to the father's. Although the adult difference in size between S1 and M1 was only 2.5 cm, S1 was taller than M1 at all ages (table 6) and taller than

TABLE 6

Difference in height between S1 and M1 at ages 3-18

AGE	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Height difference (cm)	2.1	7.4	—	6.8	7.5	8.9	8.1	7.4	6.4	8.4	10.4	10.4	6.0	3.1	2.7	3.1

any of his uncles up to the age of 16. The adolescent spurt began in the 12th year and reached its peak velocity in the 14th, a year earlier than in any of the previous generation. The relation of difference in height between M1 and S1 for ages between three and 14 has been calculated by the method of least squares with the following result. Height difference = 0.28 × age + 3.94. Table 7 gives the calculated values for the height difference at ages from 3 to 14 and also these values expressed as percentages of the height of M1 at each age.

TABLE 7

Calculated height differences between M1 and S1 at ages 3-14

AGE	3	4	5	6	7	8	9	10	11	12	13	14
Calculated height difference (cm)	4.8	5.1	5.3	5.6	5.9	6.2	6.5	6.7	7.0	7.3	7.6	7.9
Height difference as % of height of M1	5.2	5.2	4.9	4.9	4.9	4.9	5.0	5.0	5.1	5.1	5.2	5.2

At all ages from 3 to 14, S1 was about 5% taller than M1 and since he attained adolescence about a year earlier it appears that this difference was due to more rapid growth rather than to absolute greater size. During and after the adolescent spurt the difference in size was only about 2.5 cm at comparable stages of maturity, which is considerably less than the difference before adolescence and hardly significant.

DISCUSSION

Comparison of the growth of the two sexes

Since the age of onset of adolescence and of peak growth velocity varied within each sex, the mean growth curves tend to blur the sharp changes in growth rate which occurred at those times. However, they have the advantage that they tend to cancel out both small measurement errors which deform the individual curves and also any genetic variability which is equally distributed within the two sexes. Thus they enable a better general comparison to be made of the growth of the two sexes than is obtained by comparing the growth of two individuals. They show that on average the females started their adolescent spurt two years before the males, as at the present day (Tanner, '55), and that the actual duration and form of the spurt was strikingly similar in the two sexes. To demonstrate this fact the mean increments of height for

the year of maximum growth velocity and for the two preceding and three following years have been expressed in table 8 as a percentage of height.

This indicates that the specific growth-rate during the adolescent spurt (that is, growth expressed as self-multiplication of actual height) was virtually identical in the two sexes. The actual yearly height-increments at adolescence were, however, greater in the males since their

TABLE 8

Mean yearly height increments at adolescence expressed as percentage of height at beginning of year

(YEARS)	−2	−1	YEAR OF PEAK GROWTH VELOCITY	+1	+2	+3
Males	3.13	4.29	5.24	3.14	1.33	0.73
Females	2.94	4.27	5.21	3.18	2.10	1.40

absolute stature was greater at a comparable stage during the adolescent spurt. The only striking difference between the sexes was that growth in the females was more sustained in the second and third years after the year of peak growth velocity.

Order of individual size during the adolescent growth spurt

If the order of size of the members of each sex is compared in the year of maximum growth velocity and in the years preceding and following this (figure 3), it is found to be remarkably constant and corresponds closely to order of size at completion of growth, which was therefore related both to the size at which the growth spurt began and also to the size at which maximum growth was occurring. Those who were larger at any particular phase of the growth spurt were larger as adults.

S1 was consistently larger than M1 and smaller than M3 and M5 at a comparable stage of maturity, and this corresponded to his actual adult height in relation to M3, M5 and M1. Despite quicker maturation and an earlier onset of adolescence, his size during adolescence and in adult life was well within the size range of the previous generation.

Relation of size before adolescence to onset of adolescent growth spurt.

It has long been known (Baldwin '21, quoted by Tanner, '55; Boas '32) that children who are tall before puberty begin adolescence earlier than those who are short. This is only partly true because in a large group of children the tallest before adolescence are usually those who are maturing most quickly and who have the greatest skeletal age; for Bayley ('46) and Simmons and Greulich ('43) have shown that time of onset of adolescence is more closely related to skeletal than to chronological age; and size at maturity can be more readily predicted from size at a given skeletal age than from size at a comparable chronological age.

This however ignores the influence of physique on rate of development, and it has been shown by Dupertuis and Michael ('53) that ectomorphic boys are taller than mesomorphic boys before adolescence at all ages over 4 (though this finding is not statistically proven), and that they attain adolescence about a year later. Thus genetically tall individuals may mature later than genetically short ones, if their tallness is associated with greater ectomorphy.

This point may be illustrated in the present study. M3 and M5 were the tallest of the brothers during the adolescent spurt. M3 was consistently the tallest before adolescence, and M5 was the second tallest up to the age of 6. Both of them attained adolescence later than their brothers. Greater height seems to have been due in these two brothers not to greater rapidity of development but to a genetic height difference from their brothers, which could possibly have been associated with greater ectomorphy.

Among the sisters F4 and F5 reached adolescence a year earlier than F2 and F3, while F1 did so a year earlier still. F1 differed from her sisters when adult, being smaller and less mentally acute, and it is possible that a thyroid abnormality in early childhood may have accounted for her early maturity and small adult size. The growth at adolescence of F2 and F4 was strikingly similar, both in rates of acceleration and deceleration of growth and in actual size at each phase. This suggests that a genetic similarity in height was associated with a genetic difference in speed of development before adolescence, since it is unlikely that their environments could have differed sufficiently to produce a full year's difference in onset of adolescence. Thus in the sisters, unlike the brothers, greater height before adolescence (in F4 and F5) was associated with more rapid development and with earlier adolescence. In the family as

a whole there appear to be at least two independent hereditary factors affecting height at a given age, one determining height at a given stage of maturity and the other rapidity of growth and age at adolescence.

Environmental influences—secular trend towards more rapid growth

The increased rapidity of growth and maturation of S1 may reflect the secular changes in growth known to have taken place in the last 100 years in many countries; in England and Scotland (Weir '52; Clements '53), Sweden (Broman, Dahlberg and Lichtenstein '42; Abramson and Ernest '54), the U. S. A. (Meredith '41), Canada (Meredith and Meredith '44; Hopkins '47) and elsewhere. As Weir has pointed out these changes are due to an acceleration of growth prior to adolescence, giving a greater size at any given chronological age, although size in relation to skeletal age may not be increased.

Although no conclusions can be drawn from the growth of S1 in the absence of other data for the second generation, the fact that adolescence started a year earlier than for any of the previous generation of males, but that the height was no greater at a comparable stage of adolescence, is certainly suggestive of a secular change of the type which Weir ('52) describes.

SUMMARY

1. Variations of growth in height have been studied in a family of ten siblings born between 1864 and 1884.
2. The specific growth-rate during the adolescent spurt of growth was the same for both sexes. Greater increase in size of the males at this time was due to greater absolute size.
3. Two-thirds of the greater size of the males was due to a longer period of growth. The remaining third was due partly to greater absolute size before adolescence and partly to greater size increase at adolescence.
4. There was no straightforward relationship between height and time of onset of the adolescent spurt, since height at a given age was governed by two independent hereditary factors, one controlling rate of maturation and the other the height at any given stage at maturity.
5. Since the rate of growth during and after adolescence was similar for all members of the family, adult size was closely related to size at the beginning and at the peak of the adolescent spurt of growth.
6. A son of one of the brothers, born nearly 60 years after his father,

grew 5% faster before adolescence and matured a year earlier than his father. His size and growth-rate during adolescence and his adult height did not differ significantly from those of the previous generation.

7. No clear evidence was found for the existence of a juvenile growth spurt.

ACKNOWLEDGMENTS

I should like to express my gratitude to Professor J. D. Boyd of the Anatomy School, University of Cambridge, and to Dr. J. M. Tanner of the Institute of Child Health, University of London, for reading the manuscript and for giving their criticism and advice.

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COMPONENTS OF VARIANCE IN ANTHROPOMETRY*

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IT is generally agreed that the reliability of anthropometric data varies directly with the body-build of the subject, e. g., the dimensions of lean subjects are more accurately obtained than subjects with increasing amounts of subcutaneous fatty tissue. Likewise, measurements of morphological features such as height and sitting height are more reliable than those features which involve increasing amounts of subcutaneous tissue such as bideltoid diameter or elbow-elbow breadth. With regard to anthropometric studies on numerous subjects, it is obvious that the reliability of the results would increase with a decrease in the number of anthropometrists involved and with an increase in the amount of training received by the anthropometrist.

There has been some attempt in the past to determine which morphological features are most consistent. Gavan ('50) reports a study based on measurements of 62 morphological features taken by 6 teams of anthropometrists on 5 subjects. There were as least 10 measurements obtained for each feature; most were taken 30 times, and some were taken 49 times. No subject was measured by all teams. The average of the standard deviation and of the coefficient of variation were used as measures of consistency, i. e., the difference in repeated measurements when the subject and anthropometrist remain constant. This procedure allowed grouping of the morphological features into three consistency groups: high, medium, and low. However, this analysis results in a confounding of 4 sources of variation: inter-subject, intra-subject, inter-anthropometrist, and intra-anthropometrist. Only the first source of variation is reliable variance; the remaining three constitute unreliable variance.

* The opinions or assertions contained herein are the personal ones of the writers and are not to be construed as reflecting the views of the Navy Department.

In order to obtain estimates of the sources of variation and to determine the proportion of total variance contributed by each, a components-of-variance analysis of variance design was utilized in this study. By this technique confounding is avoided and the percentage of reliable and unreliable variance can be identified. The paradigm for the statistical design is given in table 4 in the Appendix.

PROCEDURE

This study was concerned with determining the morphological features which are important in determining aircrew workspace dimensions and the arrangement and location of equipment. Eleven features were selected as the ones most likely to be critical, viz., height, weight, sitting height, knee height, buttock-leg length, buttock-knee length, elbow-elbow breadth, bideltoid diameter, span, anterior arm reach, and maximum arm reach. In preparation for the measurements on these features, three individuals trained on practice subjects for a period of 4 weeks until the inter- and intra-anthropometrist variation was approximately constant. Then each anthropometrist measured 14 subjects three times on each of the morphological features employing standard anthropometric techniques as reported by Hertzberg *et al.* ('50). These measurements were obtained within a period of one week and at about the same time each day. The 42 subjects included civilian employes (37) and naval enlisted personnel (5) at the Air Crew Equipment Laboratory, who ranged in age from 19 to 68 (mean = 34.8; median = 33.5).

RESULTS AND DISCUSSION

The results of the 11 analyses are presented in tables 1-3. It can be seen that the two major sources of variance are inter-subject (reliable variance) and intra-subject (unreliable variance) and, of course, have a reciprocal relationship. The intra-subject variation in this study was of an extrinsic nature (arising from variation in posture assumed when measurement was taken), except in weight, because of the short intervals between measurements. To determine intrinsic (real) intra-subject variation, longer time intervals would have been required.

The intra-anthropometrist effect contributed none or a negligible proportion of the total variance so that for practical purposes it can be disregarded. Likewise, the inter-anthropometrist effect was nonexistent when compared against the appropriate experimental error term.

However, this term was not precise because it contained the effect of sampling errors. Therefore, an approximate test was used (described in Appendix) which enabled the deletion of this effect to make the estimate of appropriate error more precise. With this adjustment, the inter-anthropometrist effect appeared in knee height, buttock-knee length,

TABLE 1

Estimates of components of variance and the % of total variance contributed by each

MORPHOLOGICAL FEATURE	INTRA-SUBJECT VARIANCE	% OF TOTAL	INTER-SUBJECT VARIANCE	% OF TOTAL	INTRA-ANTHROP. VARIANCE	% OF TOTAL
Buttock-leg Length	6.45	19.5	26.65	80.5	*	
Height	.13	.3	37.07	99.7	*	
Weight	1.05	.30	352.66	99.68	.07	.02
Knee Height	.22	3.5	6.00	96.5	*	
Buttock-knee Length	.44	6.6	6.20	93.4	*	
Elbow-elbow Breadth	.88	9.2	8.67	90.8	*	
Bideltoid Diameter	.32	9.0	3.24	91.0	*	
Max. Arm Reach	1.92	10.8	15.77	88.2	.18	1.0
Span	1.76	4.4	40.67	95.6	*	
Ant. Arm Reach	2.30	17.4	10.68	80.8	.23	1.8
Sitting Height	.57	5.9	9.09	94.1	*	

NOTE—Inter-Anthropometrist Variance was non-existent and is not included in the table.

* Not significant; therefore, considered non-existent.

buttock-leg length, anterior arm reach, and maximum arm reach. This effect contributed the largest proportion of total variance in the last named feature (10%).

According to table 3 the morphological features which are most reliable are height, weight, span, and sitting height; the least reliable are buttock-leg length, maximum arm reach, and anterior arm reach. The great variability seen in the arm reaches is to be expected inasmuch

TABLE 2

Estimates of components of variance and the % of total variance contributed by each using the approximate test for evaluation of the inter-anthropometrist effect

MORPHOLOGICAL FEATURE	INTRA-SUBJECT VARIANCE	% OF TOTAL	INTER-SUBJECT VARIANCE	% OF TOTAL	INTER-ANTHROP. VARIANCE	% OF TOTAL	INTRA-ANTHROP. VARIANCE	% OF TOTAL
Buttock-leg Length	6.45	19.4	26.18	78.6	.67	2.0	*	
Height			no change					
Weight			no change					
Knee Height	.22	3.5	5.73	90.2	.40	6.3	*	
Buttock-knee Length	.44	6.5	5.95	88.0	.37	5.5	*	
Elbow-elbow Breadth			no change					
Bideltoid Diameter			no change					
Max. Arm Reach	1.92	10.4	14.45	78.6	1.83	10.0	.18	1.0
Span			no change					
Ant. Arm Reach	2.30	17.5	10.09	76.4	.58	4.4	.23	1.7
Sitting Height			no change					

* Not significant; therefore, considered non-existent.

TABLE 3

Percentage of total variance contributed by each component of variance

MORPHOLOGICAL FEATURE	RELIABLE VARIANCE INTER-SUBJECT	RELIABLE VARIANCE INTRA-SUBJECT	UNRELIABLE VARIANCE INTER-ANTHROP.	UNRELIABLE VARIANCE INTRA-ANTHROP.
Height	99.7	.3		
Weight	99.68	.30		.02
Span	95.6	4.4		
Sitting Height	94.1	5.9		
Bideltoid Diameter	91.0	9.0		
Elbow-elbow Breadth	90.8	9.2		
Knee Height	90.2	3.5	6.3	
Buttock-knee Length	88.0	6.5	5.5	
Buttock-leg Length	78.6	19.4	2.0	
Maximum Arm Reach	78.6	10.4	10.0	1.0
Anterior Arm Reach	76.4	17.5	4.4	1.7

as movement of the shoulder joint varies in three dimensions. Any measurement involving this joint will tend to offer a sizeable amount of unreliable variance through both intra-subject and inter-anthropometrist sources of variation.

A procedure by which to overcome the unreliability indicated in these analyses would be to obtain more than one sample of each measurement for each morphological feature, with some time interval between measurements, thereby increasing the reliability of the estimate. Such a procedure would be of special value in the conducting of anthropometric studies which are concerned with the solution of practical problems such as fitting various personnel with clothing or other equipment. However, this procedure would result in great expense. A compromise solution which would seem feasible would be to take only one measurement on those morphological features which have been indicated to be most reliable and to obtain two or more for the more variable ones.

ACKNOWLEDGMENT

The authors wish to express their appreciation to Mr. James Young of the Air Crew Equipment Laboratory for his valuable assistance as an examiner in the prosecution of the experiment.

APPENDIX

The analysis of variance model used in deriving estimates of the components of variance for the 11 morphological features is described by Harter and Lum ('55) and by Greenwood ('56). The paradigm is shown in table 4. There were three random effects, Subjects (which "nested" within Anthropometrists), Anthropometrists, and Trials, which represented Inter-Subject, Inter-Anthropometrist, and Intra-Anthropometrist sources of variation, respectively. The Subjects X Trials Interaction Within Anthropometrists is used to represent Intra-Subject variance because the entire experiment could not be replicated to give an estimate of experimental error. However, the very nature of the experiment seems to indicate that this interaction is non-existent. Therefore, σ^2ac can be deleted from the Expected Value of Mean Square column in table 4, leaving only σ^2e; σ^2e contains intra-subject variations and any other uncontrolled aspects in the experiment. However, inasmuch as the other sources of variation are considered by the Trials and by the Anthropometrist effect, σ^2e should contain only intra-subject variations.

It is obvious from the table which effects are used as the appropriate

error term for each test of significance. However, there is no test of the Anthropometrist effect unless the Trials X Anthropometrist Interaction effect is non-significant. In all analyses this effect was non-existent. Inasmuch as the question of the pooling of non-significant interactions with the error term is far from settled at the present time, a "never pool procedure" was adhered to in making tests of significance. However, the Subjects X Trials Interaction Within Anthropometrists was used

TABLE 4

Components of variance paradigm

SOURCE OF VARIATION	*df*	EXPECTED VALUE OF MEAN SQUARE
Anthropometrist (b)	2	$\sigma^2e + 14\sigma^2ab + 3\sigma^2c + 42\sigma^2b + \sigma^2ac$
Subjects Within Anthropometrists (c/b)	39	$\sigma^2e + 3\sigma^2c + \sigma^2ac$
Trials (a)	2	$\sigma^2e + 14\sigma^2ab + 42\sigma^2a + \sigma^2ac$
Trials X Anthropometrist (ab)	4	$\sigma^2e + 14\sigma^2ab + \sigma^2ac$
Subjects X Trials Within Anthropometrists (ac/b)	78	$\sigma^2e + \sigma^2ac$

σ^2a = Intra-Anthropometrist Variance; σ^2b = Inter-Anthropometrist Variance; σ^2c = Inter-Subject Variance; σ^2e = Intra-Subject Variance.

whenever it contained the same terms as the effect which was the appropriate error term, because it was based on greater degrees of freedom and, thus, it was a more reliable estimate. After all effects had been shown to be present or non-existent by tests of significance, all effects containing the same terms were pooled and estimates of the various components of variance, and the percentage of total variation contributed by each of these was obtained.

In all 11 analyses the Anthropometrist effect was non-significant when tested by the Subjects Within Anthropometrist effect. (Trials by Anthropometrist was non-existent in all 11 analyses). The Anthropometrist effect contains sampling errors and is less precise than a within-subjects effect. Therefore, an approximate test of the Anthropometrist effect was made by deleting the effects of sampling errors (σ^2c) by the following F test:

Anthropometrist mean square — Subjects Within Anthropometrists mean square + Subjects X Trials Within Anthropometrists mean square divided by Subjects by Trials Within Anthropometrists mean square.

In terms of the Expected Value of Mean Square, after the non-significant components have been deleted, this F test is as follows:

$$\frac{\sigma^2 e + 3\sigma^2 c + 42\sigma^2 b - (\sigma^2 e + 3\sigma^2 c) + \sigma^2 e}{\sigma^2 e} \text{ which reduces to } \frac{\sigma^2 e + 42\sigma^2 b}{\sigma^2 e}.$$

When this approximate test is used the Inter-Anthropometrist effect was significant in 5 of the morphological features. However, it must be emphasized that this test, even though theoretically sound in principle, must be considered as an approximation inasmuch as an appropriate test had been provided by the mathematical model. An experimental design in which all effects are within-subjects effects would overcome this difficulty and give a precise error term for all effects, e. g., a treatments X subjects design. This design would require that the anthropometrists take two or more measurements on every subject. This possibility had to be excluded in the present study because the subjects were only available for a few sessions.

To illustrate the use of this statistical design, tables 5, 6, and 7 present the data for the analysis of maximum arm reach measurements. This analysis is chosen because each of the 4 components of variance contribute to the total variation for this feature.

TABLE 5

Analysis of variance of maximum arm reach measurements

SOURCES OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	*F*	*P*
Anthropometrist	2	244.02	122.01	2.70	>.05
Subjects Within Anthropometrists	39	1765.32	45.26	23.70	<.001
Trials	2	18.90	9.45	4.95	<.01
Trials X Anthropometrists	4	8.82	2.21	1.16	>.05
Subjects X Anthropometrists Within Anthropometrists	78	148.92	1.91		
TOTAL	125	2185.98			

TABLE 6

Approximate test of anthropometrist effect

$$F = \frac{122.01 - 45.26 + 1.91}{1.91} = \frac{78.66}{1.91} = 41.18 \quad P < .001$$

TABLE 7

Estimates of components of variance for maximum arm reach measurements

SOURCE OF VARIATION	MEAN SQUARE	COMPONENTS
Anthropometrist (b)	122.01	$\sigma^2 e + 3\sigma^2 c + 42\sigma^2 b$
Subjects Within Anthropometrists (c)	45.26	$\sigma^2 e + 3\sigma^2 c$
Trials (a)	9.45	$\sigma^2 e + 42\sigma^2 a$
Subjects X Trials Within Anthropometrists (e)	1.92	$\sigma^2 e$

			Estimate of variance	*% of total*
$\sigma^2 e =$			1.92	10.4
$\sigma^2 a =$	$\frac{9.45 - 1.92}{42}$	=	.18	1.0
$\sigma^2 c =$	$\frac{45.26 - 1.92}{3}$	=	14.45	78.6
$\sigma^2 b =$	$\frac{122.01 - 45.26}{42}$	=	1.83	10.0
			18.38	100.0

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THE SUCKING BEHAVIOR IN PREMATURE INFANTS *

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INTRODUCTION

ONE of the most vital patterns of behavior in infancy is the sucking reflex. This phenomenon, though commonly observed and simple in manifestation, is perhaps one of the least understood, and has to some extent been neglected experimentally. Perusal of the medical literature reveals a dearth of information on the subject.

Sucking represents the interaction of an inborn drive and a conditioned reflex. Although it is unlearned behavior, it can be intensified, strengthened, or changed in accordance with learning experiences.

Reference to the literature reveals two principal theoretical points of orientation from which to examine the sucking phenomenon: namely, (1) the Learning theory and (2) the Psychoanalytic theory.

According to the Learning theory, sucking is regarded as a stimulus-response mechanism with hunger as the biological drive determinant. For example, when the infant is hungry and a nipple is placed in his mouth ("stimulus"), he makes spontaneous sucking movements ("response") in reaction to the applied stimulus. This is an unlearned pattern of behavior. The act of sucking, however, brings gratification and the response is rewarded and therefore strengthened ("conditioned"). As a result, the behavior pattern becomes more fixed, and increases in intensity. It has been "reinforced."

The Psychoanalytic theory holds that sucking is an instinctual form of behavior, prompted by libidinal as well as physiological needs. According to this view, infants with less opportunity to suck might be expected to show signs of emotional disturbance.

* This investigation was supported by a research grant [No. RG-3761 (CE)] from the National Institute of Health, Public Health Service.

Davis and his associates ('48) studied the effects of feeding 20 infants by cup, 20 by bottle, and 20 by breast during the first 10 days of life. During the period of study, the breast-fed infants developed a stronger sucking reflex than the other two groups, but surprisingly there were fewer signs of frustration or emotional disturbance in the cup-fed babies than in those fed by breast. Moreover, the bottle-fed infants did not, as would be expected from the Learning theory, show a sucking behavior similar to that of the breast-fed group.

A number of reports are available which describe oral behavior of infants or young animals (Brazelton, '56), but none could be located which sought to correlate the sucking reflex with the maturity of the infant. As in the case of other vital functions, the sucking reflex is established prenatally (Hooker, '42) and develops in complexity as the fetus approaches maturity. There are no clear-cut data indicating when, in prenatal life, the full potential for the sucking reflex should be reached, or in more general terms, when a plateau or leveling-off period in postnatal life occurs.

Gesell ('45) describes the behavioral characteristics of the fetal-infant (premature) whom he defines as, ". . . an individual born and living in the fetal period." He states that, " In previous studies we have followed the after-career of healthy premature infants. These studies have shown that the fundamental rates and patterns of development are little disturbed by displacements of birth. The infant remains true to his fetality—even though born before his time. He cleaves close to the inherent sequence of maturation."

Since the mechanism of sucking is developed during prenatal life, its presence, absence, and degree of intensity after birth should give some indication of gestation time. It was postulated that the maturation of the sucking behavior might follow a course parallel with or approximating that of other aspects of growth and development. If so, then the premature infant from a 7.5 month gestation period might be expected to reach his peak in sucking efficiency or maturity at approximately 1.5 months (45 days) postnatally, assuming that the reflex is fully developed in the full-term infant.

METHODS AND MATERIALS

The present study was designed to measure the fluid intake of premature infants within a prescribed time interval at regular periods during the infant's stay in the hospital, as an index of sucking power. It may be divided conveniently into three phases:

Maximum Rate of Water Intake During First Three Days of Life

First, an attempt was made to determine the sucking efficiency of the premature infant shortly after birth and throughout the first 72 hours postnatally. For this purpose, 52 Negro female [1] premature infants were fed sterile water daily at the time of the regular 9 a. m. feeding, when the hunger drive is expected to be very near maximal.

For the purpose of test-feeding, a one-ounce (30 cc) graduated bottle was used with soft rubber nipple. The opening in the nipple was 2 millimeters in length and was prepared by means of a small chisel-like blade originally used for scratch testing in allergy.

When the nipple was inserted into the mouth and the infant began sucking, a stop-clock was set. The amount of water taken in a two-minute interval was ascertained and recorded. If the infant consumed the full amount in less than the stated interval, the number of seconds required was recorded.

Individual differences in continuity of sucking were observed, but no allowance was made for pauses within the two-minute interval. In the rare instance in which a baby seemed to be sucking so fast as to choke, the nipple was withdrawn and the experiment discontinued for that day. If an infant became ill, she was dropped from the project. The sucking rate (cc of fluid consumed per second) is determined by using the simple formula,

$$\text{Rate} = \frac{\text{Volume consumed (cc)}}{\text{Time (seconds)}}.$$

It was noted that in a 30 cc bottle, approximately 0.5 cc clings to the container and cannot be removed by sucking. Hence, when the infant empties the full bottle, the intake is recorded as 29.5 cc.

Only the maximum rate of sucking efficiency is considered in this study, and this was determined simply by ascertaining the day when the infant consumed the most liquid in the least time.

Maximum Sucking Efficiency of the Premature Infant and the Normal Newborn During the First Three Days of Formula Feeding

It was deemed advisable to study the sucking behavior of a small sample of full-term infants as a frame of reference, or standard, for evaluating the observations made on premature infants. For this purpose 32 normal newborn Negro infants were tested during the first three days

[1] Only females were used inasmuch as males were the subjects of another study.

of life in a manner identical with that described above, except that a standard evaporated milk formula (20 calories per ounce) was used instead of sterile water. The results obtained were compared with those which followed the performance of premature infants who were fed the premature nursery formula (24 calories per ounce) from the fourth to the sixth day of life.

Maximum Sucking Rate Beyond the First Postnatal Week

The premature infant population provided an excellent opportunity to observe the baby for a long period of time in the nursery, as opposed to the full-term infants whose length of stay rarely exceeded 72 hours. This prolonged period of hospitalization thus made it possible to ascertain, more nearly, the ultimate maximum sucking rate. Daily contact was maintained with 52 Negro premature infants, through test-feeding with nursery formula at the 9 a. m. feeding period, as described above, for periods varying from 9 to as long as 57 days.

Results

Maximum Rate of Water Intake During First Three Days of Life

When fed sterile water during the first 72 hours of life, it was observed in general that, of the 49 premature infants tested, the heavier babies demonstrated a stronger and more effective sucking reflex (figure 1). When a Chi-Square test was performed, the association between birth weight and maximum rate of water intake was found to be direct and highly significant (1% level of confidence).

The mean maximum sucking rate for water for the 49 infants during the first three days of life was 0.16 cc per second, while that for formula during the fourth to the sixth day of life was 0.25 cc per second. This, however, does not quite reach the accepted level of statistical significance for a mean difference.

There is a direct association between the maximum water rate and maximum formula rate, indicated both by regression analysis and by Chi-Square. Thus, infants with a high water rate tended to have also a high formula rate. The Phi coefficient of correlation, corrected for dichotomized variables, was 0.7948 for the 49 infants studied.

Early Maximum Sucking Rate in Premature and Full-Term Infants

Maximal sucking rate data, collected during the first week of life, are available on 51 premature and 32 full-term infants. The descriptive data on the full-term infants reveal the wide range of sucking efficiency

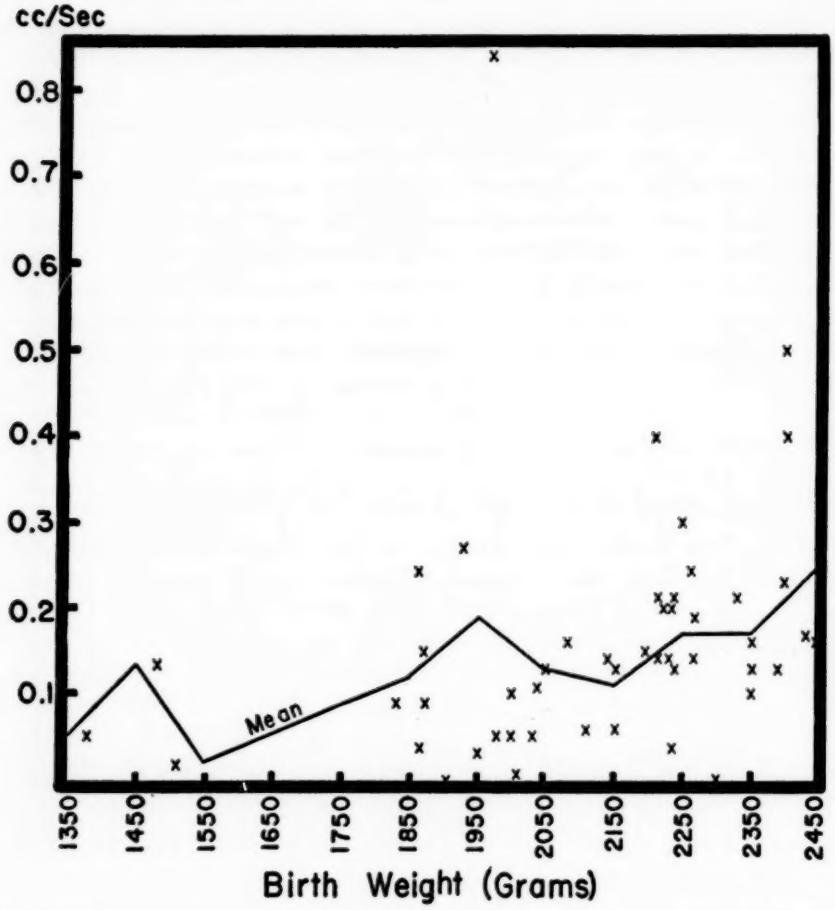

FIG. 1. MAXIMUM SUCKING RATE (STERILE WATER) OF 49 PREMATURE INFANTS DURING FIRST THREE DAYS OF LIFE, BY BIRTH WEIGHT.

found in normal newborn babies (0.2-1.2 cc per second) and demonstrate, moreover, that the sucking rate of a given full-term infant is more or less independent of his birth weight. Figure 2 reveals the

superior performance of the full-term newborn (0.6 cc per second) during the first three days of formula feedings, as compared with the premature infant (0.24 cc per second). A gross comparison of the maximal sucking efficiency of premature and full-term infants would be

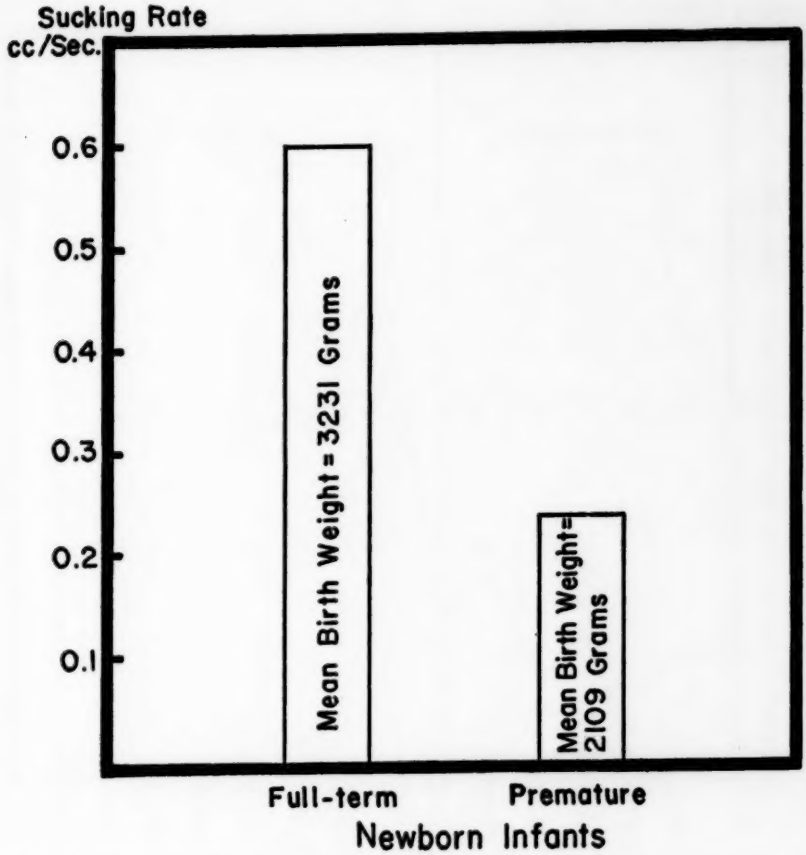

FIG. 2. MAXIMUM SUCKING RATES (MEAN) WITHIN FIRST THREE DAYS OF FORMULA FEEDING (32 FULL-TERM AND 51 PREMATURE INFANTS).

expected to show a significant difference in intake during the first week of life. A finer level of discrimination is necessary, however, to determine if a progressive correlation exists between the sucking rate and the infant's weight at birth. Figure 3 reveals the maximum sucking rates of infants, during the first three days of formula feeding, with birth

weights ranging from 1380 to 4050 grams. A significant, direct association is shown between the birth weight of premature infants and sucking efficiency. It is observed that, in general, the larger the premature infant at birth the greater his sucking rate. While it is apparent

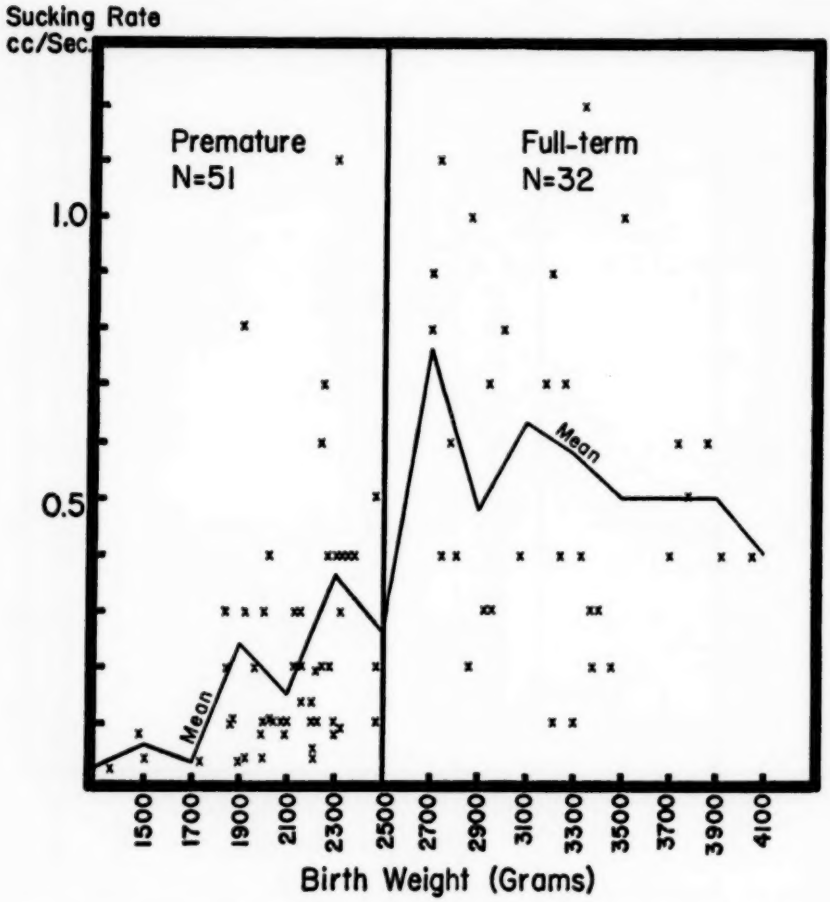

FIG. 3. MAXIMUM SUCKING RATE OF 83 NEWBORN INFANTS DURING FIRST THREE DAYS OF FORMULA FEEDING, BY BIRTH WEIGHT.

that, with respect to position on the birth weight scale, no such progressive association between birth weight and sucking efficiency exists within the full-term group, there is a general tendency toward a plateau or leveling-off of the sucking rate among mature newborn infants, without particular regard to relative size at birth.

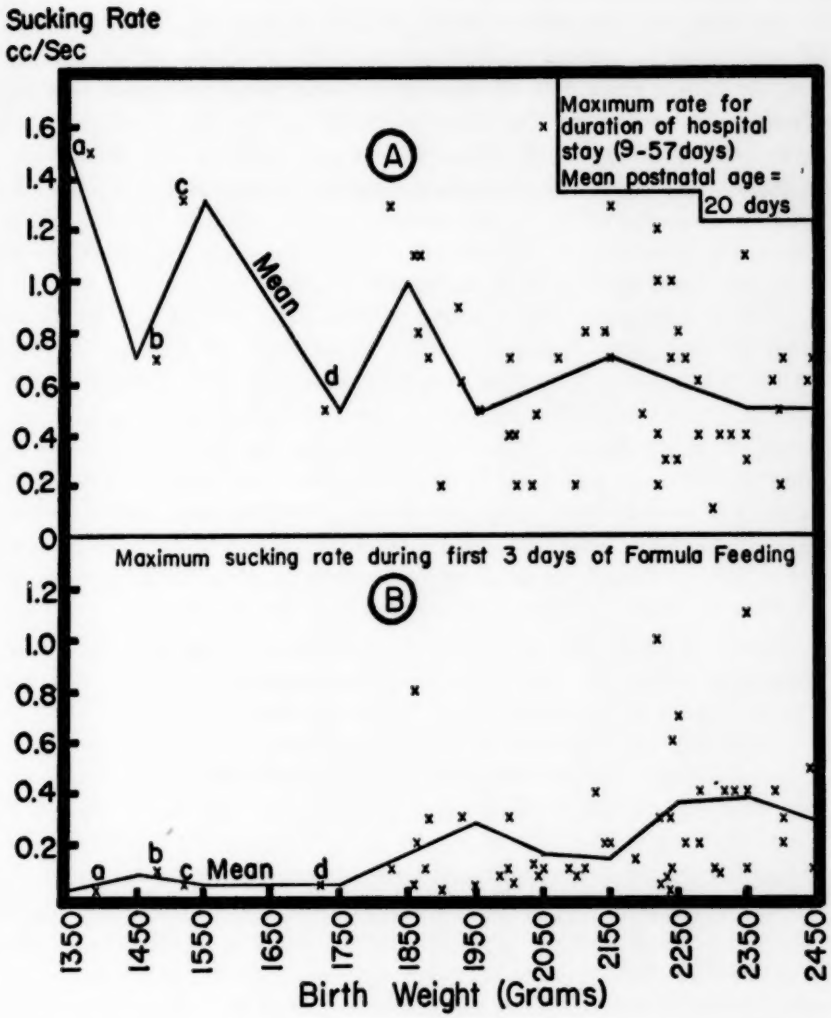

FIG. 4. MAXIMUM SUCKING RATE OF 51 PREMATURE INFANTS FOR (A) DURATION OF HOSPITAL STAY AND (B) FIRST THREE DAYS OF FORMULA FEEDING, BY BIRTH WEIGHT.

Later Maximum Sucking Rate

Because premature babies remained in the nursery for varying periods of time, data on maximum sucking rates are available on 52 infants, ranging in age from 5 to 51 days at the time when maximum sucking efficiency was achieved. The mean postnatal age for the group at maximum rate of intake is 20 days. It was postulated at the outset that in the case of premature infants, a progressive association is likely to exist between size at birth and efficiency of the sucking mechanism as the infant grows older postnatally. In general, this hypothesis seems to be confirmed by data from the present study.

The positive association existing between birth weight and the maximum sucking rate during the first three days of formula feeding (figure 4-B) seems to be obscured later when the same infants (figure 4-A; a, b, c, d) are followed for a longer period of time to ascertain the point at which the highest sucking rate, for the entire period of hospitalization, is achieved. It must, however, be borne in mind that figure 4-A relates birth weight to maximum sucking rate without regard to postnatal age. Moreover, perusal of figure 5 will reveal that infants, a, b, c and d, though smallest by birth weight, are among the oldest [2] postnatally when the maximum sucking rate was achieved.

Figure 6 shows the relationship between the postnatal age of 52 premature infants at the time when the maximum sucking rate was achieved and the age at discharge from the hospital. It will be noted coincidentally that, in most instances, the infant was sent home within three to 5 days after achieving the maximum efficiency in sucking, and that at discharge the babies ranged in age from 9-57 days. Ideally, it would have been desirable to retain all infants in the hospital for a uniform duration of time and to compare the observed maximum sucking rate following identical periods of observation. Inasmuch as the larger babies went home first, the question arises, "Does the maximum sucking rate observed during hospitalization represent the ultimate maximum rate for these infants?" In other words, "Will the rate continue, for a time, to rise following discharge, and then stabilize at a higher level?" This question we cannot answer. However, figures 1 and 3 indicate that sucking operates at a relatively low level of efficiency in the newborn infant (prematures 0.24 cc per second; normal newborns 0.6 cc per second) during the initial phases of feeding. Given time, however, this

[2] 38, 35, 46 and 50 days respectively.

rate rises with varying degrees of rapidity in the premature infant (figure 4-A). These observations, taken together, lend support to the postulate that the maturation of the sucking mechanism parallels other aspects of growth and development in prematures.

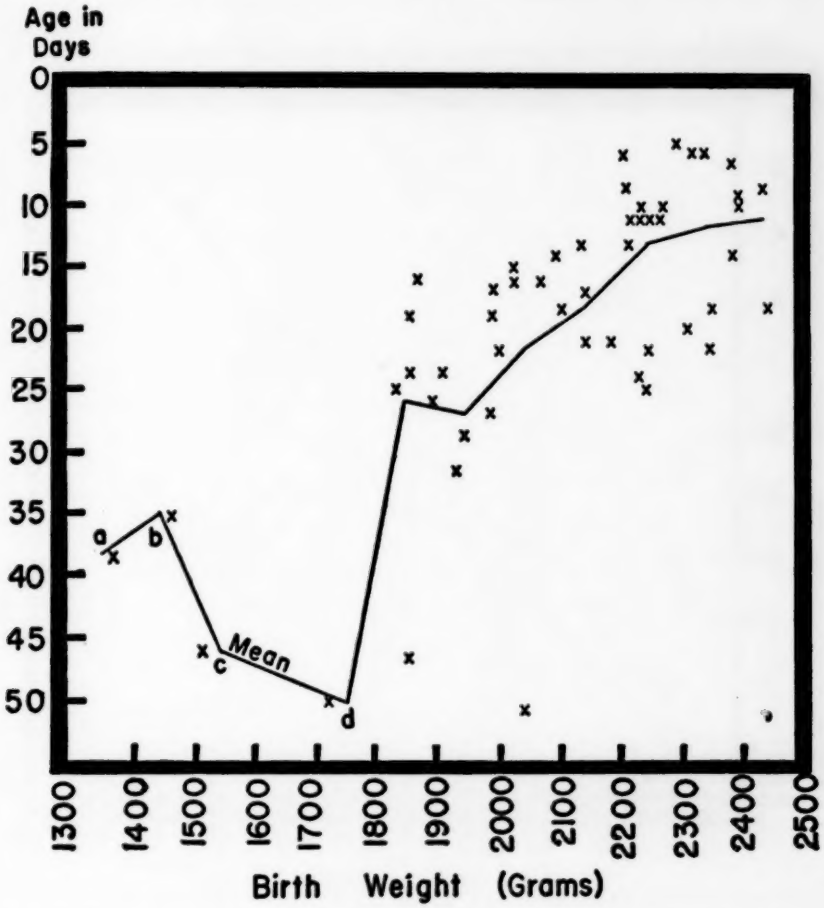

FIG. 5. POSTNATAL AGE OF 51 PREMATURE INFANTS WHEN MAXIMUM SUCKING RATE WAS ACHIEVED, BY BIRTH WEIGHT.

Postnatal Age and Maximum Sucking Rate

Generally speaking, the heavier the premature infant at birth, the younger he was, in terms of postnatal age, when the maximum sucking rate was achieved (figure 5). For example, the average postnatal age

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at which maximal efficiency in sucking was determined for infants whose birth weight was less than 2000 grams was 30 days, while the corresponding age for those weighing 2000-2500 grams was 15 days.

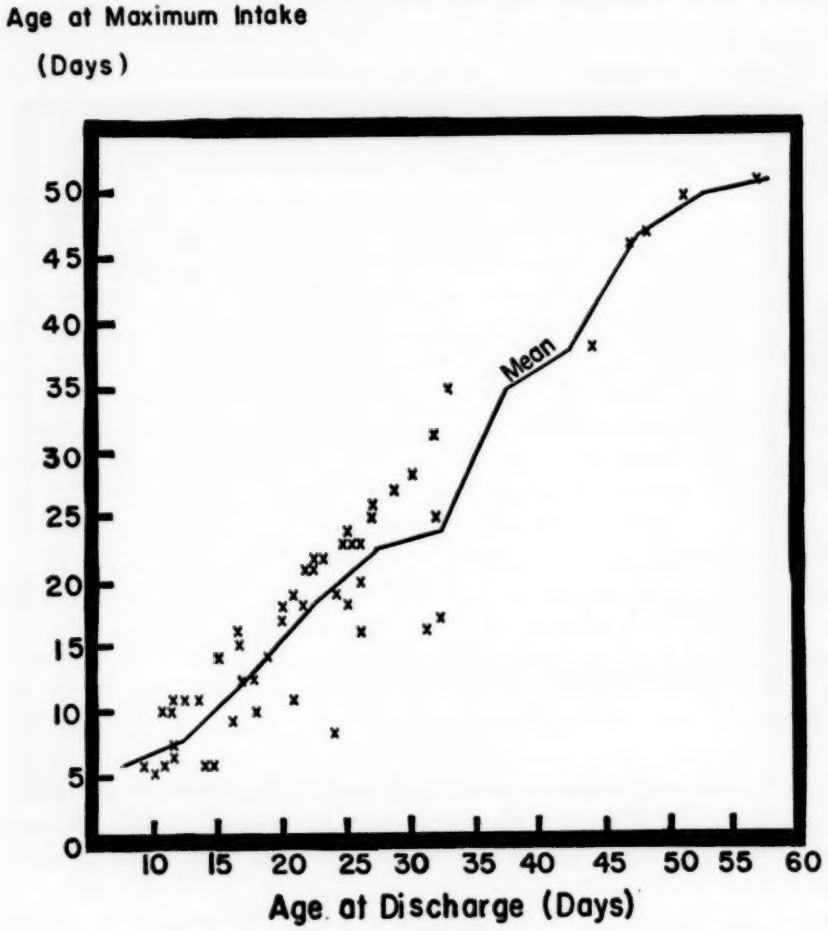

FIG. 6. POSTNATAL AGE IN DAYS WHEN MAXIMUM SUCKING RATE WAS ACHIEVED, BY POSTNATAL AGE IN DAYS AT DISCHARGE FROM HOSPITAL, FOR 52 PREMATURE INFANTS.

A Chi-Square test for independence between postnatal age when the maximal sucking rate was observed and the magnitude of the maximal rate revealed a positive association, significant at the 5% level of confidence (figure 7).

Relationship of Gestational Age to Maximal Sucking Efficiency

Age of gestation [3] was available for 23 of the 52 premature infants studied. Scattergrams prepared for these 23 revealed no significant association between the following:

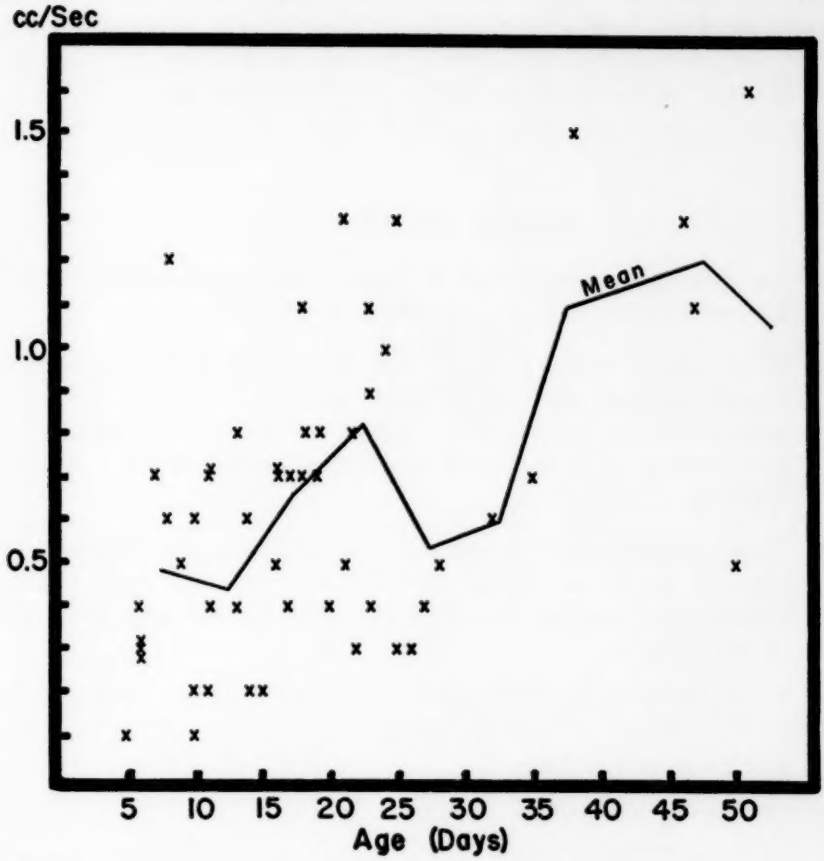

FIG. 7. MAXIMUM SUCKING RATE OF 52 PREMATURE INFANTS DURING HOSPITALIZATION PERIOD, BY POSTNATAL AGE AT WHICH MAXIMUM WAS ACHIEVED.

1. Gestational age and fastest sucking rate during the first three days of formula feeding.
2. Gestational age and the postnatal age at which the maximum sucking rate was achieved.

[3] Gestational age was secured from clinical record of mother and was generally based on her statement regarding last menstrual period.

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The lack of significant association between gestational age and maximal sucking rate during the first three days of formula feeding is somewhat surprising, inasmuch as sucking rate and birth weight were found to be related. It is perhaps possible that the small number of cases studied obscured the relationship. On the other hand, it is well known that gestation period estimates are open to many serious inaccuracies, and that, not infrequently, such estimates do not seem to correspond with the birth weight of the infant nor with the apparent fetal age.

SUMMARY AND CONCLUSIONS

1. The maximal sucking rate of 52 Negro female premature infants and 32 normal newborn Negro infants was studied.

2. It was found that during the first three days of life, premature infants ingested water at a mean maximal rate of 0.16 cc per second. The heavier babies demonstrated a stronger and more effective sucking reflex and thus achieved a higher maximal rate of efficiency.

3. When compared with the normal newborn during the first week of life, the premature infant showed a sucking rate (0.24 cc per second) averaging less than 50% of that of the full-term baby (0.6 cc per second).

4. Unlike the premature, the full-term baby during the first three days of life showed no relationship between his maximal sucking rate and his weight at birth.

5. As postulated, the sucking efficiency of the premature infant appears to follow a regular course of development with advance in postnatal age, the smallest infants generally achieving a maximal rate significantly later than larger babies. Infants whose birth weight was less than 2000 grams required, on the average, 30 days to show maximal efficiency, while those weighing 2000-2500 grams required 15 days.

6. No relationship was found to exist between gestational age and the maximal sucking efficiency of the 23 premature infants on whom complete data are available.

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CORRECTION TO Philip Levine's article, "The Influence of the ABO System on Rh Hemolytic Disease," which appeared in the February 1958 issue (Vol. 30, No. 1):

The 17 cases listed in table 1 (p. 16) as "antibodies" are erroneously referred to in the Addendum as "antibodies but no hemolytic disease." The original table in the paper by Owen, *et al.* (*Proc. Nat. Acad. Sci.*, *40*: 420-424), stated that the findings were "based on antibody determinations only," but actually (p. 423) there was severe hemolytic disease in 6, mild disease in 2; 4 infants were apparently not affected, and one mother was still pregnant. As anticipated, the findings in the two contrasting groups totaling 51 cases revealed an excess of ABO compatible matings in the 17 cases (13 ABO compatible, three incompatible, one no data) and an excess of ABO incompatible matings in the 34 cases with no antibodies (18 compatible and 16 incompatible).

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DATA FOR QUANTITATIVE GENETICS IN MAN. BIRTH WEIGHT IN OFFICIAL STATISTICS

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INTRODUCTION

THE genetical implications of birth weight as a metrical character have received attention in recent times by Karn and Penrose ('51), McKeown and Gibson ('51), Penrose ('54), Robson ('55), Morton ('55), Fraccaro ('56), Haldane ('57) and others. These studies were based usually on two types of material, either on a series of births in consecutive years from one maternity clinic or on all births in a town in a given time unit. In the first type the information is definitely relevant but the size of the sample is necessarily rather small, e. g., 13,730 in the study of Karn and Penrose ('51); 5,486 in that of Fraccaro ('56). In the second, the size of the sample is larger, e. g., 23,970 births in Birmingham in 1947 as assembled by McKeown and Gibson ('51). A special case is the Japanese data assembled by the Atomic Bomb Casualty Commission (cf. Neel and Schull, '56), which have also been discussed by Morton ('55).

It is possible at this time to extract a very large sample from Czechoslovakian official statistics, which contains information on birth weight of all new born babies, classified by vitality and sex. My attention was called to these data during the U. N. O. World Population Conference in Rome in 1954, when the Czechoslovakian delegation presented a short summary of similar data assembled in 1950 (Proc. World Pop. Conf., '54). I found it of some interest to explore what kind of information could be extracted from this material. I obtained the data in the form presented here through the courtesy of Dr. Frantisek Fajfr.

THE MATERIAL

Information was obtained for a total of 167,731 births which took place in the Czech territory of Czechoslovakia (*i. e.*, former Bohemia, Moravia and Silesia) in 1955. These births include the following categories:

(a) fetuses after 28 weeks of gestation with a minimum length of 35 cm and a minimum weight of 1000 gm,

(b) fetuses not complying with (a) but live born and surviving at least 24 hours,

(c) fetuses complying with neither (a) nor (b) but produced by a multiple birth of which at least one fetus complies with (a) or (b).

Sex distribution and the number of live-births and stillbirths are given for different birth weight groups, divided into class intervals of 500 gm. The distribution of parity (order of birth) and mother's age for different weight groups is also listed, but this material is not divided by sex. Parity and maternal age are not listed concurrently for each birth weight class. The birth order is based on all previous live and still births. Ninety-two per cent of the sample is said to be reported from maternity clinics. The information obtained is given in table 1.

ANALYSIS

Table 2 gives the means and standard deviations for birth weight according to sex and vitality. As expected the stillborn babies are lighter even though those weighing less than 1000 gm have been excluded. This exclusion makes the mean higher than expected. Comparison with other data regarding this point is difficult. For example, the English and Italian data, assembled by Karn and Penrose ('51) and Fraccaro ('56), included both stillbirths and neo-natal death without the weight limitation of 1000 gm under the definition of non-survivors. The mean parity (first-born $= 0$) and mother's age are 1.33 (S. D. $= 1.53$) and 26.94 (S. D. $= 5.57$) respectively. The common anomaly of the prevalence of first-borns is not found in this large sample, in which the mean parity is much higher than in the smaller samples (cf. mean parity 0.90 for all births in Karn and Penrose and 1.05 in Fraccaro). The information obtained has listed maternal age and parity separately as related to birth weight. Had both these variables been listed for each individual birth weight simultaneously, the analysis could have been taken further

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TABLE 1

All births in the Czech territory (former Bohemia, Moravia and Silesia), 1955 *

CLASS LIMITS		BIRTH WEIGHT -999	1000-1499	1500-1999	2000-2499	2500-2999	3000-3499	3500-3999	4000-4499	4500-4999	5000-	UNKNOWN	TOTAL
Live-births	Males	46	470	1,093	2,975	11,603	31,416	27,054	9,268	1,443	190	22	85,580
	Females	76	472	1,075	3,470	15,427	34,033	20,260	4,813	575	65	28	80,294
Still-births	Males	7	143	158	138	172	189	130	56	10	10	3	1,016
	Females	8	122	138	127	146	162	91	27	13	5	2	841
Parity	0	40	453	980	3,051	12,965	25,467	13,969	2,784	271	32	11	60,023
	1	38	313	671	1,633	7,252	20,446	16,266	4,961	651	81	12	52,324
	2	24	184	399	921	3,543	10,162	8,717	2,946	457	55	7	27,415
	3	20	125	193	509	1,649	4,836	4,210	1,645	265	37	9	13,498
	4	5	60	84	273	887	2,320	2,009	804	167	19	6	6,634
	5	4	29	61	144	439	1,166	1,023	436	96	18		3,416
	6	2	14	37	72	270	632	585	251	49	10	4	1,926
	7	2	13	11	47	145	321	325	127	30	3	1	1,025
	8	1	7	9	23	72	186	189	96	22	4		609
	9 and over	1	9	19	37	125	263	242	114	33	11	2	856
	unknown					1	1					3	5
Maternal age	-15		2	1	3	6	10	3			1		26
	15-19	9	91	272	762	2,715	5,151	2,600	499	51	6	3	12,159
	20-24	41	417	824	2,467	10,741	24,346	16,019	4,004	453	49	16	59,377
	25-29	47	344	642	1,724	7,440	19,741	15,406	4,753	681	74	21	50,873
	30-34	25	204	451	1,087	4,358	11,459	9,370	3,273	550	81	4	30,862
	35-39	8	102	162	416	1,338	3,352	2,788	1,092	198	34	2	9,492
	40-44	7	41	99	235	686	1,620	1,256	496	103	25	5	4,573
	45-49		4	13	15	57	115	90	47	5			346
	50 and over		1		1	4	1	3					10
	unknown		1			3	5					4	13
TOTAL		137	1,207	2,464	6,710	27,348	65,800	47,535	14,164	2,041	270	55	167,731

* The information is in the form obtained.

and the individual contribution of the two variables been estimated. The correlation between birth weight and parity, as calculated from table 1, is 0.112 ± 0.0022, and that between birth weight and mother's

TABLE 2

Means and standard deviations of weight for live-births and still-births and their total*

SEX OF INFANT	VITALITY	NO.	BIRTH-WEIGHT (gm) MEAN	S. D.
Male	Live-births	85,558	3,412.09 ± 1.90	556.65
	Stillbirths	1,013	2,649.31 ± 29.89	951.25
	Total	86,571	3,403.17 ± 1.93	568.80
Female	Live-births	80,266	3,274.99 ± 1.84	521.35
	Stillbirths	839	2,571.81 ± 31.71	918.40
	Total	81,105	3,267.71 ± 1.87	531.80
Both sexes	Live-births	165,824	3,345.73 ± 1.34	544.20
	Stillbirths	1,852	2,614.20 ± 21.78	937.30
	Total	167,676	3,337.65 ± 1.36	555.35

* The standard deviations given in tables 2-4 are adjusted with Sheppard's correction.

TABLE 3

Mean birth weight for given parity (all births)

PARITY	NO.	MEAN	S. D.
0	60,012	3,220.50	520.70
1	52,312	3,388.52	538.45
2	27,408	3,409.84	563.15
3	13,489	3,420.40	593.40
4	6,628	3,419.28	599.85
5	3,416	3,427.00	624.80
6	1,922	3,427.68	619.65
7	1,024	3,419.43	632.40
8	609	3,483.99	651.15
9 and over	854	3,435.01	683.50
TOTAL	167,674	3,337.15	554.50

age is 0.090 ± 0.0024. The latter is generally reduced when corrected for parity, which is not possible here, since the correlation between age and parity is not available.

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Tables 3 and 4 show the mean birth weight values and their standard deviations for each parity and maternal age. The mean birth weight increases with parity. The increment is more evident between the first and the second birth, when the mean weight increases by 0.3 of σ, and it is still significant between the second and the third births. In the higher parities the mean weights remain rather constant.

TABLE 4

Mean birth weight for given maternal age (all births)

MATERNAL AGE	NO.	MEAN	S. D.
-15	26	2,942.31	812.30
15-19	12,156	3,180.53	532.65
20-24	59,361	3,296.85	531.80
25-29	50,852	3,376.11	547.85
30-34	30,858	3,396.87	570.20
35-39	9,490	3,386.88	613.15
40-44	4,568	3,360.00	632.65
45-49	346	3,332.37	648.90
50 and over	10	2,900.00	
TOTAL	167,667	3,337.67	555.35

According to previous studies (among others, Millis and Seng, '54; Neel and Schull, '56) the relationship between birth weight and parity is consistent and generally of a curvilinear type, while mother's age has a negative effect when parity effects are removed. The parabolic distribution of mean birth weights for given mother's age which is observed in table 4 is probably not real. Unfortunately the official statistics do not provide weights for given mother's age and parity, and therefore they do not allow an efficient analysis on this point. It is worth noting, however, that while Millis and Seng ('54) observed in their material that mean birth weights at different maternal ages for all parities are fitted by a straight regression line (cf., figure 4, p. 67 in their paper), in the present data the mean birth weights at different maternal ages as given in table 4 are fitted by a parabola.

Table 5 shows the stillbirth rates for various birth weight groups for males and females respectively. The stillbirth rate is higher in males, the females being lower by $0.14 \pm 0.05\%$. The overall stillbirth rate in the sample is 1.10%. The fact that stillborn babies weighing less

then 1000 gm are not included should be remembered in judging these rates. The heavy elimination of the very light and very heavy babies by stillbirth is evident from table 5. The babies weighing between 3000 and 4000 gm have the best chance of being alive at birth, while only

TABLE 5

Still birth rates for given birth weight

BIRTH WEIGHT (gm)	MALES			FEMALES		
	ALL BIRTHS	STILL BIRTHS	STILL BIRTH RATE (per cent)	ALL BIRTHS	STILL BIRTHS	STILL BIRTH RATE (per cent)
- 999	53	7	13.21 ± 4.65	84	8	9.52 ± 3.20
1000-1499	613	143	23.33 ± 1.71	594	122	20.54 ± 1.66
1500-1999	1251	158	12.63 ± 0.94	1213	138	11.38 ± 0.91
2000-2499	3113	138	4.43 ± 0.37	3597	127	3.53 ± 0.31
2500-2999	11775	172	1.46 ± 0.11	15573	146	0.94 ± 0.08
3000-3499	31605	189	0.60 ± 0.04	34195	162	0.47 ± 0.04
3500-3999	27184	130	0.48 ± 0.04	20351	91	0.45 ± 0.05
4000-4499	9324	56	0.60 ± 0.08	4840	27	0.56 ± 0.11
4500-4999	1453	10	0.69 ± 0.22	588	13	2.21 ± 0.61
5000-	200	10	5.00 ± 1.54	70	5	7.14 ± 3.08
TOTAL	86571	1013	1.17 ± 0.04	81105	839	1.03 ± 0.04

about 80% of the babies in the weight group 1000-1500 gm are live births. An estimate of the birth weight associated with optimal vitality at birth is given by the ratio

$$\frac{m_{LB} \times V_{SB} - m_{SB} \times V_{LB}}{V_{SB} - V_{LB}},$$

where m and V are the mean and the variance of livebirths (LB) and stillbirths (SB) (cf. Fraccaro, '56).

These estimates are 3809 gm for males and 3609 gm for females. They are higher than the means by 0.7 and 0.6 of a standard deviation unit, respectively. The same estimates calculated using the variance unjusted for grouping effect are 3836 gm and 3635 gm respectively. I have discussed the selective importance of differential mortality associated with birth weight in a previous paper (Fraccaro, '56), and further discussion on this point can be found in Haldane ('57) and McKeown ('57).

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CONCLUSION AND SUMMARY

The data on birth weight of 167,731 births in the Czech territory included in the Czechoslovakian official statistics have been briefly examined. Mean birth weight is higher in males than in females for both categories of live- and stillbirths. As expected, stillborn babies are lighter than liveborn.

Stillbirth rates for given birth weight groups have been calculated. They show the selective effect of birth weight at the extremes, where very light and very heavy babies show high stillbirth rates. The overall stillbirth rate is 1%. The stillbirth rate for the birth weight group 1000-1500 gm is about 20% and for the weight group above 5000 gm about 6%.

An estimate of the birth weight associated with the optimal vitality at birth, gives values above the mean.

The effect of parity of the mother and maternal age on birth weight cannot be efficiently estimated from the present data, which unfortunately do not give the two variables for any birth weight group simultaneously. However, mean birth weights for given parity and mother's age have been calculated and presented.

The introduction into official statistics of more biological data of the nature reviewed in this paper is to be warmly welcomed, although such data are not always fully suitable for immediate fruitful analysis. Their accumulation will, however, prove of extreme value to future students.

ACKNOWLEDGMENT

I wish to acknowledge the courtesy of Dr. Frantisek Fajfr, president of the National Statistical Office, Praha, who kindly provided the data discussed in the paper. Thanks are also due to Mr. E. Lander, Uppsala, for help with some of the calculations and to Dr. K. Hirschhorn, New York, for reading the manuscript.

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REFLECTOMETRY OF THE SKIN IN SOUTHERN NIGERIANS AND IN SOME MULATTOES *

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INTRODUCTION

REFLECTOMETRIC techniques offer a more objective method for the quantitative study of pigmentation than do the earlier visual scoring and matching procedures. Edwards and Duntley ('39a) and Sheard *et al.* ('26) explored the reflectometry of normal human skin, and the method has also found a use in work on sunburn (Edwards and Duntley, '39b, Jansen, '53) and in endocrinological studies (Lerner *et al.*, '54, Edwards *et al.*, '41; Edwards and Duntley, '49).

The recent introduction of inexpensive, portable reflectometers has opened up the possibility of population surveys for anthropological purposes and of more accurate work on the genetics of pigmentary differences. Lasker ('54) has reported some data on a Mexican population, and pigmentary changes with age have been studied by Garn *et al.* ('56) who examined several different skin areas in white subjects of both sexes. Harrison ('57) has given an account of his work on Negro-European hybrids.

The present paper, based on material collected in Southern Nigeria in January-April, 1956, deals with the skin color of two indigenous peoples who are compared with one another and with Europeans, and also with the skin pigmentation of a small sample of African-European hybrids, mainly from Warri in the Niger Delta region.

* The tables of original data for this investigation have been deposited as Document number 5532 with the ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D. C. A copy may be secured by citing the Document number and by remitting $1.25 for photoprints, or $1.25 for 35 mm microfilm. Advance payment is required. Make checks or money orders payable to: Chief, Photoduplication Service, Library of Congress.

THE SAMPLE

One hundred Yoruba males and 94 Yoruba females attending the general medical clinic at the Adeoyo Hospital, Ibadan, were measured. Their ages, which were only known approximately, ranged from 18 to 60 years. The majority (101) of the Yoruba subjects gave Ibadan as their birthplace; 30 were born in Ijebu; 17 in Abeokuta; and the remainder in various other parts of Yoruba country. Fifty male Ibo students at the University College, Ibadan were also measured; 21 of these came from Onitsha; 11 from Owerri; and 8 from Awka. Finally, measurements were also made on 14 male Yoruba students from the University, Ibadan.

The European sample which was measured in London a year later, and therefore in the winter months, comprised mainly academic staff, students and technicians at University College, London. Two persons of German birth, one Italian, and one Swede were also included.

TECHNIQUE

A portable Evans Electroselenium Company reflectometer (Weiner, '51) was used and the measurements were taken on the flexor surface of the right forearm at the junction of the middle and proximal thirds. Tatoo marks had to be avoided in the Yoruba women. The site was cleaned by gently wiping with cotton-wool soaked in soapy water. A magnesium carbonate block, which could be periodically cleaned, served as a white standard and readings were taken with 9 color filters, the transmission maxima of which are shown in table 1. To check the performance of the instrument readings on gray paper standards at filters 601 (blue) and 609 (red) were interspersed with the skin readings. During the later part of the work, a second, somewhat lighter standard was established and was also used in England. Successive readings on these standards showed no significant trend over the period of the experiments, and agreement between readings in Nigeria and in England was close. The standard deviations of the sets of readings obtained on the two standards in both countries varied between 0.52% and 0.66% and were closely similar at the two ends of the spectral range. The instrumental error is therefore small in relation to readings on European skin, but may amount to some 8% of the reading on African skin in the blue end of the spectrum. It must be remembered that the quite small

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errors arising from variations in pressure when placing the photometer-head on the arm are not included in the readings on the standards.

The work at Ibadan was done in air-conditioned rooms and the instrument behaved satisfactorily, but in the high temperatures and humidities of the Delta, deterioration of the photocell occurred if it was exposed for too long to the air. This trouble was met by keeping the photocell-head in a dessicator when not in use and minimizing the exposure to humid atmospheres.

It is perhaps worth emphasizing that the reflectance curves obtained with different types of instrument will not necessarily be the same since differences in the optical system, in the characteristics of the filters, if such are used, and in the light source may cause the results to diverge. Comparing, for example, the curves for the skin of the same European subject on the Evans Electroselenium Company instrument and the General Electric Company Hardy recording spectrophotometer, we found the readings with the former to be about 25% higher at 435 mμ and about 4% lower at 685 mμ.

RESULTS

In table 1 the mean reflectances at each wave length and the standard deviations are set out for each of the various samples, and the results are shown graphically in figure 1. The mean values of reflectance at each wave length constitute the basic data from which indices of overall lightness and darkness and hue can be derived; they are also the essential data for the calculation of energy absorption in the visible range. The mean of the readings at 9 wave lengths may be taken as an approximate measure of overall lightness/darkness irrespective of the particular pigments or optical effects concerned, and the values of these means are also given in the tables.

As a measurement of pigmentation due to melanin the reading at 685 mμ (filter 609) is the most suitable, since as Jansen ('53) and others have pointed out, the amount of oxygenated blood in the skin affects the readings very little in the red region. We found that venous congestion with a sphygmomanometer cuff may lower the reading at this wave length by about 10% in a European; however, these are extreme conditions and in ordinary circumstances variations in blood supply are likely to have much less effect; in Africans, due to masking of the blood by melanin, they are even less important.

TABLE 1.

Mean percentage reflectance and standard deviation (in parentheses) at 9 filters for African and European samples

SEX	SAMPLE	NO.	WAVE LENGTH OF TRANSMISSION MAXIMUM AND FILTER NO.									MEAN REFLECTANCE NINE FILTERS
			601 426 mμ	602 470 mμ	603 490 mμ	604 520 mμ	605 550 mμ	606 580 mμ	607 600 mμ	608 660 mμ	609 685 mμ	
MALE	Yoruba Med. Clin.	100	8.0 (0.91)	8.3 (1.00)	8.1 (1.17)	9.7 (1.43)	10.1 (1.15)	10.9 (1.54)	14.3 (3.08)	20.6 (3.51)	23.6 (3.79)	12.6 (1.84)
	Yoruba Students	14	7.9 (0.67)	7.7 (0.56)	7.7 (0.58)	9.1 (0.59)	9.3 (0.78)	10.1 (0.85)	13.2 (1.22)	19.6 (1.91)	22.9 (2.05)	11.9 (0.93)
	Ibo Students	52	8.7 (1.12)	9.2 (1.23)	9.3 (1.40)	10.7 (1.56)	11.2 (1.73)	12.6 (2.15)	17.0 (3.14)	24.6 (4.05)	28.2 (4.14)	14.6 (2.19)
	Europeans	50	32.8 (3.84)	39.7 (3.99)	41.4 (4.07)	41.6 (3.90)	37.9 (3.72)	41.4 (3.64)	52.4 (4.05)	59.9 (2.90)	61.5 (2.77)	45.4 (3.37)
FEMALE	Yoruba Med. Clin.	94	8.5 (0.80)	8.9 (1.07)	8.9 (1.19)	10.5 (1.33)	11.1 (1.83)	12.2 (2.02)	16.2 (2.85)	23.1 (3.64)	26.1 (4.17)	13.9 (2.04)
	Europeans	50	34.3 (3.48)	41.4 (3.93)	43.1 (3.90)	43.9 (3.76)	40.5 (3.79)	43.9 (3.55)	54.3 (2.95)	61.5 (2.72)	63.1 (2.34)	47.3 (3.09)

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The distributions of the readings at 685 mμ are shown in figure 2. The African distributions are somewhat skewed, which is to be expected at the lower end of the percentage scale, but it was not considered necessary to correct for this in making statistical comparisons. The relation between the reflectance and the actual amount of melanin in

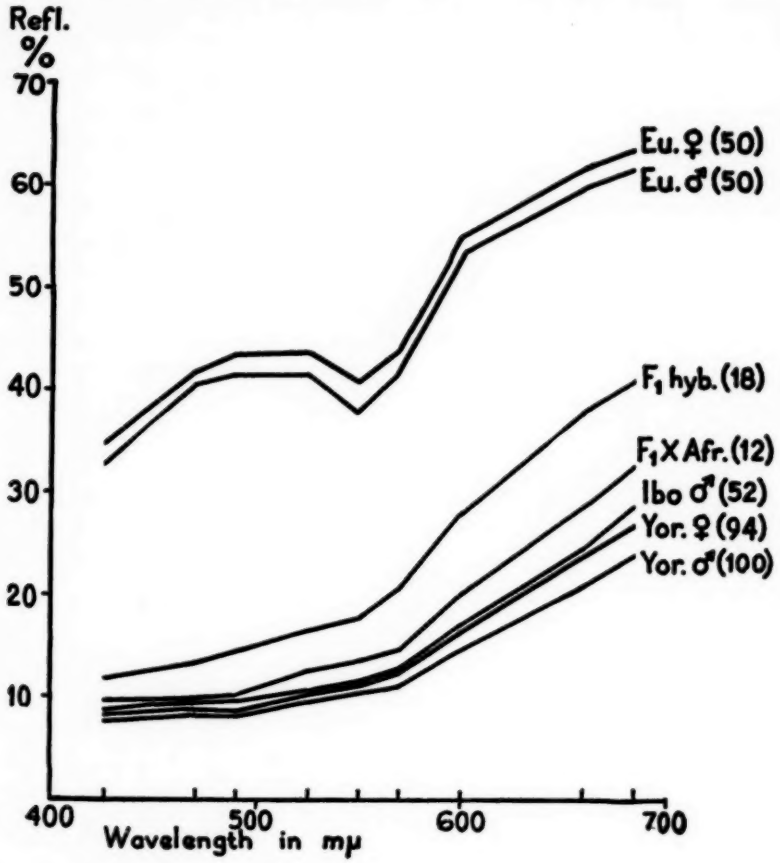

FIG. 1. CURVES DRAWN THROUGH THE MEAN REFLECTANCE VALUES AT EACH OF 9 WAVE LENGTHS FOR EUROPEAN, AFRICAN AND HYBRID SAMPLES.

the skin would have to be established empirically since the optical properties of skin are complex and the application of simple absorption laws may not be justifiable.

The curves for European males and females are similar in shape but the reflectance of the males is lower at all wave lengths. The males

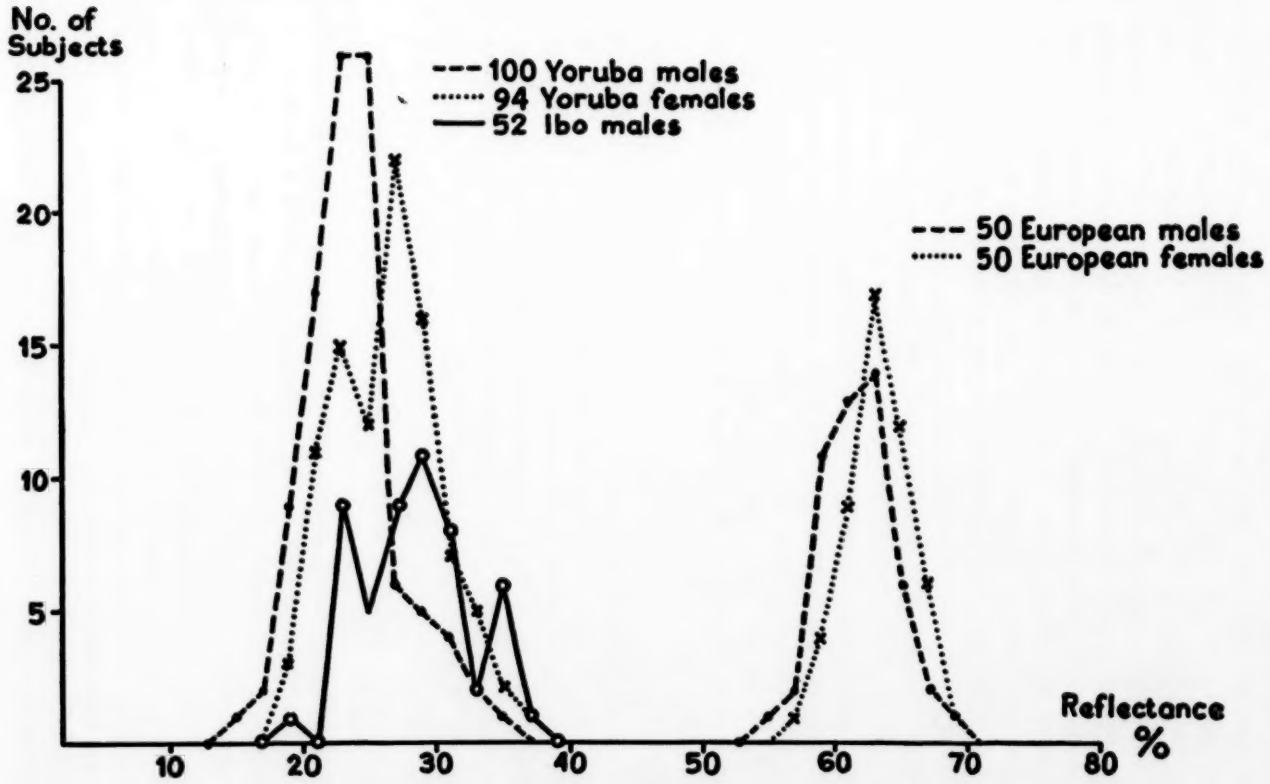

FIG. 2. DISTRIBUTIONS OF PERCENTAGE REFLECTANCE AT 685 mμ (Filter 609) FOR AFRICAN AND EUROPEAN SAMPLES.

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also show somewhat greater variability at all wave lengths. It will be noticed that in both sexes the variability, compared as the coefficient of variation, is very considerably greater in the blue and green regions than in the red, due presumably to the fact that variations in the blood supply exert their main effects in this region. Comparing the male and female readings at 685 mμ we find "t" for 98 d. f. is 2.32, significant at the 5.0% level. The more superficial position of the large veins and the presence of dark hair on the arm in some male subjects must be taken into account in interpreting this sex difference in reflectance. Garn *et al.* ('56) also noted a tendency for the reflectance of male subjects to be lower; their measurements, however, were made at 420 mμ only, a region in which not only melanin but also haemoglobin absorbs strongly, and the effects of the two pigments are therefore seriously confused.

Lower reflectances in the males were also found in the case of the Yoruba samples; again comparing the mean readings of the two sexes at 685 mμ, we obtain "t" for 192 d. f. equals 3.09 which is significant at the 1.0% level. This difference may be due at least in part to differences in sun-tan, since this part of the arm is more often exposed in African males than in females.

Comparing the Yoruba males from the medical clinic with the Ibo students in the same way, we obtain "t" = 4.76 for d. f. 148, which is significant at the 0.1% level, thus confirming local opinion that the Ibos are the lighter skinned. The variance of the Ibos is greater but not significantly so. The Ibo students may also be compared with the Yoruba students. Due to the rather lower mean and considerably lower variance of the latter as compared with the medical clinic sample, we again obtain a significant difference ("t" = 3.77, d. f. 62, $P = 0.001$).

Hybrid samples

The measurements on hybrid subjects were mostly obtained in the towns of Warri and Sapele. The results are summarized in table 2. They comprise 18 adults who were the children of matings between an African mother of the Jekri tribe (except in one case) and a European father who was generally English or Scottish. In some cases these hybrids, who may be regarded as an F_1, had children by an African or by another F_1 hybrid, and the results for a few offspring of such crosses are also shown in table 2.

The Jekri people have a long history of miscegenation with Europeans with whom they came in contact as traders. Local feeling places no

obstacle in the way of obtaining details of the pedigree in these cases. We were particularly fortunate in having the assistance of Miss O. A. Igrakpata, the Senior Social worker at Warri, the town in which she was born, in obtaining the full cooperation of the families. According to notes on the social position of mulattoes kindly supplied by Mr. P. Lloyd of the Institute of Social and Economic Research, Ibadan, the majority of the mulattoes are offspring of their mother's first liaison and are often the eldest and only children, with whom the mother comes to live in her old age. Some marry Africans and are fully accepted into African society, and most of them are prosperous and become wealthy by trading or by running sewing-schools, etc.

Unfortunately, because of the effects of the climate on the instrument and shortage of time, it was impossible to measure an adequate sample of Jekri women to represent the maternal side of these crosses. There is no reason to think, however, from what little work we were able to do and from general observation, that the Jekri differ in pigmentation from the Yoruba who are linguistically related to them.

The mean reading at 685 mμ for the F_1 hybrids is 41.0 (table 2), which is close to the mid-value (43.8) between the means of the Yoruba females and European males, who may be taken to represent the parental populations. It must be remembered, however, that the mean of the latter would doubtless be lower if they had been exposed to sunshine to the same extent as the Nigerians. The variance of the F_1 hybrids (28.27) is substantially higher than that of the Yoruba females (17.38), but the coefficients of variation are similar. The mean of the "backcross" of F_1 hybrids to Africans (table 2) is 32.3, which is close to the mid-value of 32.0 between F_1 hybrids and Yoruba males, while the mean of F_2 offspring (table 2) is 39.6 which is almost the same as the F_1 mean (41.0), but there is no evidence of increased variance.

The data are insufficient to justify elaborate biometric analysis and an attempt to find a consistent scale compatible with an additive form of multifactorial inheritance. The percentage reflectance scale necessarily produces bunching of the values at the two ends. It is worth noting that if the raw reflectances are transformed by the expression Log R-log (100-R) as used by Sunderland ('55) in work on hair color, the variance of the Yoruba females (0.0079) is brought close to that of the F_1 hybrids (0.0094) without affecting the relationship between the means of the three samples very much. The variance of the European males (0.0026) remains much lower; the low variance of this sample is no doubt partly due to the minimal exposure to sun-tanning.

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TABLE 2

Mean percentage reflectance and standard deviation (in parentheses) of African hybrids

MATING TYPE OF PARENTS	NO. OF OFFSPRING MEASURED MALE	NO. OF OFFSPRING MEASURED FEMALE	APPROX. AGE RANGE IN YEARS	REFLECTANCES AT 9 WAVE LENGTHS 426 mμ	470 mμ	490 mμ	520 mμ	550 mμ	580 mμ	600 mμ	660 mμ	685 mμ	MEAN OF 9 WAVE LENGTHS
European male *X* African female [1]	4	14	30-65	12.0 (2.13)	13.1 (2.45)	14.2 (2.99)	16.4 (3.34)	17.6 (3.76)	20.3 (4.37)	27.9 (5.48)	37.4 (5.64)	41.0 (5.36)	22.4 (3.79)
F_1 hybrid *X* African [2] (5 families)	4	8	6-25	9.5 (1.30)	9.8 (1.51)	10.0 (1.94)	12.4 (2.40)	13.1 (2.60)	14.4 (3.42)	20.0 (4.81)	28.1 (6.66)	32.3 (6.00)	16.5 (3.36)
F_1 hybrid *X* F_1 hybrid (4 families)	2	5	One 48 remainder 3-10 yr.	12.0 (1.67)	12.4 (2.00)	13.6 (2.04)	15.7 (2.38)	17.1 (2.91)	20.6 (3.65)	27.4 (4.28)	35.8 (5.06)	39.6 (4.94)	21.4 (3.19)

[1] All the African mothers were Jekri except one who was Ibo. The European fathers were English (7), Scottish (7), German (2), Portuguese (1), Lebanese (1).

[2] In all cases except one, one parent was a Jekri-European hybrid and the other Jekri; in one case the father was Jekri-German and the mother Urhobo.

The assumptions involved in interpreting results on material of this kind should be carefully examined. It is not improbable that Africans and Europeans have some pigmentation genes in common so that evidence of segregation might be apparent in the variance of the first generation hybrids and would decrease the difference of variance between this generation and the F_2, which is a classical criterion of mendelian effects in experimental material. The influence of environmental factors, in particular sun-tanning, on the mean and variance may well be different between hybrids and the general population, since F_1 hybrids tend to enjoy a more sedentary indoor existence. It seemed likely that one or two of the male subjects were sun burned, however, so that the range of variation may be unusually great. One cannot safely assume, as Kuppenheim and Heer's ('52) work seems to indicate, that the relative effect of sun-tanning will be the same at all levels of initial pigmentation. The likelihood of some degree of assortative mating should be borne in mind when dealing with a character such as skin color, but the close correspondence between the means of the hybrids and the mid-parental values suggests that this factor has not been important in the present case.

SUMMARY

1. The reflectance of the skin on the flexor surface of the forearm in some African and European subjects has been measured at nine filters covering the visible spectrum.
2. The reflectance is found to be lower in male subjects, both African and European.
3. The Yoruba of Southwestern Nigeria are shown to be somewhat darker than Ibo from the Southeast.
4. Some reflectance data on the offspring of crosses between Europeans and Africans (F_1) and of certain other crosses is presented as a contribution to the genetics of skin color differences.

ACKNOWLEDGMENTS

The work was done during a visit to Nigeria financed by a grant from The Rockefeller Foundation. I am grateful to the Department of Medicine, University College, Ibadan, for providing laboratory accommodation and also some of the subjects, and to Professor C. W. L. Bevan, Professor J. Grayson and Mr. R. O. Thomas for providing access to others. I am also indebted to Mr. Preston of the National Physical

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Laboratory for advice regarding reflectometry and to my wife for assistance in the field investigations.

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BOOK REVIEWS

Sports in the Cultural Pattern of the World: A Study of the 1952 Olympic Games at Helsinki. By ERNST JOKL, M. J. KARVONEN, JAAKKO KIHLBERG, AARNI KOSKELA and LEO NORO. VII + 116 pp. Helsinki: Institute of Occupational Health, 1956. No price indicated.

The chronic effects of physical exercise are of very real interest to students of growth and development and of other aspects of human biology. There is an urgent need for longitudinal investigations on such fundamental problems as the consequences, if any, of athletic participation of girls on the development of the pelvis, asserted to be narrower in female athletes. Only longitudinal studies will help to separate the factors of selection from the real somatologic effects of athletics.

In the present volume a group of scientists examined Olympic participation and athletic performance in reference to the characteristics of the individual athletes (age, sex) and of the countries (such as climate, death and birth rates, and nutrition) which they represented at the Summer Games.

Methodologically, of interest is the novel method of allocating points for various Olympic performances, based on ranking the competitors. The winner is assigned 100 points, the last man 0 point, with the intermediate point scores (P) assigned on the basis of the formula $P = 100 (1 - \log x / \log n)$, where $x =$ ordinal number of the competitor, $n =$ the number of competitors in an event. When n is given, P is a linear function of the logarithm of the competitor's rank (x). Examples of the point allocation system are given both in tabular and graphic form for groups varying in the number of participants.

A wealth of data is presented in the text and in the appendixes, including the number of participants from the various countries, actual and related to population size (participation rate); number of points collected, given as absolute figure (point share), as points per million inhabitants (point rate), and as average number of points collected in the events in which a country's representatives participated (point level).

Olympic participation and achievement is presented in reference to eight geographical regions, with the highest point level attained by the U. S. S. R. (41.6) and United States plus Canada (37.1). The highest

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point rate was held by Europe (124.5); the corresponding value for North America was 64.6, for the U. S. S. R., 45.0.

As to sex, the high standards of physical performance of women, attested at Helsinki, leads the authors to call for a re-examination of the traditional reserve with which the physical training of women is frequently treated by educators and physicians. The authors believe that scientific studies of women's athletics indicate that biologically the female sex is more robust and more capable of adjusting to the demands of physical activities than has been generally assumed. The extension of the age span of women athletes participating in top-level competition, noted at Helsinki, is interpreted as reflecting the process of acceleration of growth and of deceleration of aging.

Paragraph 40 of the Olympic Rules specifies that "There is no age limit for competitors in the Olympic Games." The age range of the participants—from boys and girls of 13 to 14 to women of 45 and men of 66 years—is truly amazing. Different competitive events show distinct age patterns; thus male swimmers averaged 21.5 years while the median age of competitors in shooting events was 37 years. The authors are careful to point out that average ages of top-level performers can in no way serve as indicators of the suitability of the particular sport for purposes of attaining or maintaining physical fitness.

In regard to relation between racial background and performance, the White race was dominant in the longer runs and in the throwing events while the Negro race played a major role in the shorter runs. The representatives of Asiatic populations, though few in number, were successful in many sports events. It is of interest, from several points of view, that the three most outstanding long-distance swimmers—while competing on behalf of the United States, Japan and Brazil—were all of Asiatic racial stock.

Here, and in relating Olympic performance to size of the countries, their climate, vital statistics and economic conditions we deal with complex, partly interrelated factors. The association with performance scores must be interpreted with caution. What is the real significance of the empirically established tendency to a positive correlation between the average caloric consumption per person for a country and the point level attained at the Olympic games, an observation that is considered as "one of the most important results of this survey" (p. 81)?

The volume, though slim, contains a large amount of information, carefully processed statistically, that is of interest to specialists in the

scientific study of athletics as well as from a more general biological point of view. There are photographs, 24 tables, 27 figures and 5 appendixes.

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The Aleut Dentition: A Correlative Study of Dental Characteristics in Eskimoid People. By COENRAAD F. A. MOORREES. x + 196 pp. Harvard University Press, 1957. $4.50.

The book contains a readable discussion of the various characteristics and problems attendant to dentitions generally. This, together with simple and comprehensive definitions of terms used in comparative odontometry, will appeal to human biologists.

Moorrees' description deals with dental materials obtained by Harvard's Peabody Museum expedition to the Aleutian Islands in 1948. Laughlin, who headed the expedition, considers the contemporary Aleuts as belonging to two breeding isolates, eastern and western. According to Moorrees, Laughlin's hypothesis is based on anthropometric, serologic, ethnologic and linguistic differences between the two groups. The distribution of blood groups confirms the racial origin of the Aleut as Eskimoid, with only a slight degree of white mixture.

Moorrees observes that the dentition offers a distinct advantage for differentiating between eastern and western Aleuts because of the large number of independent characteristics that can be studied. He believes that while the east-west differences reported in his book in no way settle the issue, they provide important material for the evaluation of Laughlin's hypothesis. The *torus mandibularis* is highly prevalent among the Aleuts. Twenty-six percent of the western Aleuts and 61% of the eastern Aleuts had this exostosis, and the regional difference was statistically significant. In both regions, males not only have a greater prevalence of tori, but also a greater frequency of the most pronounced ones. One interesting finding was that no incisors or premolars were found missing in either jaw in the available cases. An absence of one or more third molars, however, occurred in a much larger percentage than is commonly found in other population groups.

In addition to details of morphology, Moorrees discusses problems of nutrition, health and dental caries. With minor variations, the main source of food still is the sea but various birds are also available. Seagull eggs, a variety of berries and greens such as wild celery, and the bulbs of a Kamchatka lily, similar in use and composition to the potato, supplement the diet.

The results of the comparison of the average daily food intake for a limited group of Aleut women showed that the protein, fat, vitamin A, niacin and vitamin D intake levels exceeded the NRC standards, due mainly to the use of salmon and seal oil. Moorrees proposes "that the increase in the incidence of dental disease among contemporary Aleuts is associated with an unfavorable change in the quality of their tooth structure. This change in turn may be one of the inevitable by-products of a decline in general health and of rather marked changes in the dietary during the first half of the twentieth century. The great increase in the intake of refined carbohydrates may have placed an additional burden on the already weakened dental tissues by producing certain unfavorable changes in the immediate environment of the teeth. Substantiation of these speculations would require access to factual data that is not available at present."

As the preceding quotations show, Moorrees is extremely conscientious in not giving overemphasis or oversignificance to any of the features which he discusses in his book. In a section at the front of the book, preceding the text, is an interesting assemblage of 41 figures, including charts, photographs, drawings and tables. Scattered through the text are 57 tables which embellish and give substance to the discussion. It is regrettable that the sample size of Aleuts is so small.

This book is well organized and well executed. It was used as one of the texts in the course on Hominid Dentition at the University of Chicago this year.

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BOOK NOTICES

HUMAN HISTOLOGY. By Leslie Brainerd Arey. ix + 337 pp. W. B. Saunders, Philadelphia, 1957. $6.50. Standard in scope, unorthodox in treatment (a "textbook in outline form") and designedly without illustrations.

SCIENTIFIC STUDY OF SOCIAL BEHAVIOUR. By Michael Argyle. xiii + 239 pp. Philosophical Library, New York, 1957. $6.00. Part I deals with methodology, Part II with generalizations and theories of social interaction. The final, large chapter is concerned with human relations in industrial, military and similar social organizations.

MODERN RESEARCHER. By Jacques Barzun and Henry F. Graff. xiii + 386 pp. Harcourt, Brace & Co., New York, 1957. $4.50. An unconventional attempt by two historians to combine initiation into techniques of (humanistic) research with the cultivation of the art of expression. It is refreshing to read that facts *never* "speak for themselves"—they must be given an intelligible voice.

PHYSICAL AND CHEMICAL BASIS OF INHERITANCE. By G. W. Beadle. 47 pp. University of Oregon Press, Eugene, Ore., 1957. $1.00. Presented in the Condon Lectures series designed to interpret the results of significant scientific researches to the nonspecialist.

FUNCTIONAL NEURO-ANATOMY. By A. R. Buchanan. 362 pp. Lea & Febiger, Philadelphia, 1957. $7.50. Third, revised edition of a textbook presenting economically the essential material. Appended is an atlas of brain stem and adjacent structures (pp. 262-335).

PHYSICAL METHODS IN PHYSIOLOGY. By W. T. Catton. xi + 375 pp. Philosophical Library, New York, 1957. $10.00. Presents, in an abbreviated form, selected techniques applied to physiological investigations of blood, muscle, peripheral nerves and of the processes of circulation, respiration and heat exchange. The concluding chapter discusses electronics in physiology.

FATS IN HUMAN NUTRITION: SYMPOSIUM. 131 pp. Council on Foods and Nutrition, American Medical Association, Chicago, Ill., 1957. No price indicated. In recent years, interest in the subject of the symposium (6 papers and panel discussion) has been stimulated markedly by findings suggesting that dietary fat may be implicated in the genesis of atherosclerosis and coronary heart disease, previously considered as an inevitable consequence of aging.

GUIDE BOOK TO RESEARCH DATA FOR ARID ZONE DEVELOPMENT. Edited by B. T. Dickson. 191 pp. UNESCO, Paris, 1957. $6.00. Concerned with aspects that should be covered in a preliminary survey of arid or semi-arid lands as a basis for development plans. Part I is devoted to physical and biological factors, Part II to human factors. The usefulness of several of the bodily characteristics recommended for study (p. 144) appears to be highly questionable.

BRAINPOWER QUEST. Edited by Andrew A. Freeman. xiv + 242 pp. Macmillan, New York, 1957. $4.75. Proceedings of a symposium on providing adequate engineering and scientific manpower, sponsored by the Cooper Union for the Advancement of Science and Art and attended by educators, scientists and men of affairs.

MOVEMENT OF THE HEART AND BLOOD IN ANIMALS. By William Harvey. xii + 299 pp. C. C. Thomas, Springfield, Ill., 1957. $3.50. The classical Latin work on blood propulsion translated afresh and competently by K. J. Franklin.

EXPERIMENTAL PSYCHOPATHOLOGY. Edited by Paul H. Hoch and Joseph Zubin. x + 275 pp. Grune & Stratton, New York, 1957. $6.50. The proceedings of the 45th Annual Meeting of the American Psychopathological Association represent well the main currents in this field. The collaboration of clinicians and experimentalists, fostered by the Association, is important for bringing about the emergence of a common vocabulary, an experimentally oriented science of abnormal behavior, and a scientifically grounded therapy.

PRE-EMPLOYMENT DISABILITY EVALUATION. By William A. Kellogg. xv + 155 pp. C. C. Thomas, Springfield, Ill., 1957. $10.50. A detailed reference manual for medical examiners. Gives (on p. 86) tables for height and weight, without clothing, for men and women 15, 20, 25 and 30 years old. The means are "adjusted" for three types of body build, without specifying as to how "body build" is determined in actual practice.

BIBLIOGRAPHIE DER SPORTMEDIZIN UND IHRER GRENZGEBIETE 1955 (Bibliography of Sport Medicine and of Neighboring Fields). By E. J. Klaus. 96 pp. Georg Thieme, Stuttgart, 1956. $0.85. References to German publications for the year 1955 with a detailed index.

NOMINA ANATOMICA. By Fr. Kopsch. Revised by K. H. Knese. xi + 155 pp. Georg Thieme, Stuttgart, 1957. $1.55. With the Basel (1895) anatomical nomenclature arranged in alphabetical order as a basis, the terminology accepted at Jena (1935) and revised in Paris (1955) is given in parallel columns.

LIGHT, COLOUR AND VISION. By Yves Le Grand. xiii + 512 pp. John Wiley, New York, 1957. $11.00. Translated from French, this is a detailed account of the eye as a receptor of radiant energy. Section A gives experimental facts, presented from the point of view of the physicist and addressed to those who can apply them (opticians, illuminating engineers, architects). Section B deals with theories of vision.

HISTORICAL BACKGROUND OF CHEMISTRY. By Henry M. Leicester. viii + 260 pp. John Wiley, New York, 1956. $6.00. The development of chemistry is followed in reference to the ideas of chemists rather than their biography. Final chapter is devoted to biochemistry.

SOME APPLICATIONS OF BEHAVIOURAL RESEARCH. Edited by Rensis Likert and Samuel P. Hayes, Jr. 333 pp. UNESCO, Paris, 1957. $3.25. Dr. Likert

opens the volume with the manifesto on "Behavioral Research: A Guide to Effective Action." The applications are described with reference to problems of industrial management, training of leaders, marketing and business forecasting.

THE MERCK MANUAL. Edited by Charles E. Lyght. xv + 1870 pp. Merck, Rahway, N. J., 1956. $6.75. This is a physician's manual. Non-medical scientists may find of interest the sections on diets (which includes the perennial "ideal weight" weight tables for individuals of different frame, again without any numerical specification of "frame"), laboratory procedures, and formulas for conversion of measurements.

SPECIES PROBLEM. Edited by Ernst Mayr. ix + 395 pp. American Association for the Advancement of Science, Washington, D. C., 1957. $8.75. The problem of species is relevant to many branches of biology—systematics, genetics, ecology, but also physiology, behavioral sciences and applied biology. Consequently, in the present volume the Science of Species is approached by the seven contributors from several angles and on the basis of diverse materials. The editor contributed a stimulating final chapter on "Difficulties and Importance of the Biological Species Concept."

MEASUREMENT OF LEVELS OF LIVING, WITH SPECIAL REFERENCE TO JAMAICA. By C. A. Moser. 106 pp. Her Majesty's Stationery Office, London, 1957. 13s. 6d. A distinction has been made between *levels* and *standards* of living, the former referring to actual living conditions of a people, the latter to their aspirations or expectations. The author singled out for study four aspects of levels of living: education, nutrition, health and housing (with some consideration given to income and expenditure).

FEDERAL FUNDS FOR SCIENCE. By National Science Foundation. iii + 60 pp. U. S. Government Printing Office, Washington, D. C., 1957. $0.40. The report provides detailed information on the expenditures of Federal agencies engaged in scientific research and development. The size of this operation is indicated by the fact that in fiscal year 1957, 23 agencies of the Federal Government obligated over $3 billion for these purposes.

CHEMICAL DYNAMICS OF BONE MINERAL. By W. F. Neuman and Margaret W. Neuman. xi + 209 pp. University of Chicago Press, 1958. $5.00. Several disciplines contribute to the growing knowledge of bone. The present work is offered as a synthesis of current physicochemical and biochemical facts and views, with surface chemistry of the mineral substance of bone as the foundation.

CEREBRAL CORTEX OF MAN. By W. Penfield and T. Rasmussen. xv + 248 pp. Macmillan, New York, 1957. $7.00. Based on some 400 brain operations carried out under local anesthesia, with positive evidence derived principally from cortical stimulation and negative evidence from cortical ablation, the monograph deals with the role of the cortex in perception, motor mechanisms, vocalization and arrest of speech, memory and dreams.

MANUAL OF NUTRITION. 67 pp. Philosophical Library, New York, 1957. $3.50.

Introduction to the principles of human nutrition, prepared in Great Britain by the Scientific Adviser's Division of the Ministry of Agriculture, Fisheries and Food.

RHYTHMIC AND SYNTHETIC PROCESSES IN GROWTH. Edited by Dorothea Rudnick. vii + 217 pp. Princeton University Press, Princeton, 1957. $7.50. The proceedings of the 15th symposium of the Society for the Study of Growth and Development consist of three sections, dealing, respectively, with recent advances in tissue culture methods, cyclic activities, and problems of biochemical evolution with emphasis on photosynthesis.

ANIMAL BEHAVIOR. By John Paul Scott. xi + 281 pp. University of Chicago Press, 1958. $5.00. Rare are the textbooks that may be read with pleasure by the student and have appeal to readers outside the captive audiences of a classroom. This, the reviewer believes, is one of them. Implications for human psychology are not ignored but the development of general theories of behavior is considered as the principal goal of the science of animal behavior.

A CLASSIFIED BIBLIOGRAPHY OF GERONTOLOGY AND GERIATRICS. By Nathan W. Shock. xxviii + 525 pp. Stanford University Press, Stanford, Calif., 1957. $15.00. The supplement registers close to 16,000 publications in all segments of this broad field. Contains an index of authors and subjects.

TRENDS IN GERONTOLOGY. By Nathan W. Shock. viii + 214 pp. Stanford University Press, Stanford, Calif., 1957. $4.50. Second edition, surveying major developments since 1950. It brings together many facets of the study of ageing and provides key references with illustrative data. Of special interest are the chapters on "Trends in research" and "Research potentials."

NUCLEAR RADIATION IN FOOD AND AGRICULTURE. Edited by W. Ralph Singleton. xii + 379 pp. D. Van Nostrand, Princeton, N. J., 1958. $8.50. Readers of this journal may be particularly interested in Part V of this volume (one of the outgrowths of the Geneva Conference, August 1955, on Peaceful Uses of Atomic Energy), dealing with genetic and biological hazards of nuclear radiation. Two papers (p. 259, 272) consider implications to human biology.

NO AND YES. By René A. Spitz. xii + 170 pp. International Universities Press, New York, 1957. $4.00. The author is engaged in a broad study of the ontogenesis of the ego from a psychoanalytical viewpoint. This report on the beginnings of language is the 6th in a series of investigations of man's early development.

BODY WATER IN MAN. By Maurice B. Strauss. xix + 286 pp. Little, Brown and Company, Boston, 1957. $7.00. Synthesis of the evidence that man is provided with distinct mechanisms for the regulation of the amount as well as the composition of the body fluids (thirst and appetite controlled by the central nervous system, and kidneys functioning under the influence of circulatory, hormonal and possibly neurogenic factors).

SCIENCE IN PROGRESS. Edited by Hugh Taylor. xv + 253 pp. Yale University Press, New Haven, Conn., 1957. $6.50. Tenth in the series, this volume presents reports of prominent scientists in a variety of fields, including Vannevar Bush's thoughtful essay on "Science and Progress?", the detective story by K. P. Oakley and J. S. Weiner about the hoax of "Piltdown Man," and R. R. Williams' "Chemistry as a supplement to agriculture in meeting world food needs."

PSYCHOLOGICAL RESEARCH. By Benton J. Underwood. vii + 298 pp. Appleton-Century-Crofts, New York, 1957. $4.00. The book's purpose is to aid in training psychology students in scientific method, with emphasis on experimental research. It may be perused with profit by all persons interested in the methodological issues vital to contemporary study of behavior.

SCIENTIFIC AND TECHNICAL TRANSLATING AND OTHER ASPECTS OF THE LANGUAGE PROBLEM. 282 pp. UNESCO, Paris, 1957. $4.00. This volume, published in the series entitled "Documentation and Terminology in Science," deals with selected aspects of international scientific communication, with emphasis on the translations. The appendixes, in addition to other materials, contain a bibliography for technical-language study.

A GLOSSARY OF SOME TERMS USED IN THE OBJECTIVE SCIENCE OF BEHAVIOR. By William S. Verplanck. viii + 42 pp. American Psychological Association, Washington, D. C., 1957. $1.00. Aimed principally at increasing mutual intelligibility between ethnologists (usually trained in zoology and studying the behavior of insects, fishes and birds rather than of other groups) and behaviorists (usually trained in psychology, emphasizing the study of learning, and building their theories often on the behavior of the white rat). Not irrelevant for the study of human behavior.

STRATEGY OF THE GENES. By C. H. Waddington. ix + 262 pp. Macmillan, New York, 1957. $4.00. Essays in theoretical biology, dealing with the nature of biological organization and the theory of evolution. Noted here on account of the synthesis of the point of view of developmental biology and population genetics.

METHODOLOGY OF THE STUDY OF AGEING. Edited by G. E. W. Wolstenholme and Cecilia M. O'Connor. x + 202 pp. Little, Brown and Company, Boston, Mass., 1957. $6.50. This volume is the third in the outstanding Ciba Foundation Colloquia on Ageing. It covers many approaches and facets of gerontology, from the study of cells and tissues to the consideration of whole organisms; from data on the egg production in hens and rattlesnakes to changes in human performance with age. Presentation of papers is followed by extended discussions. Changes in body composition were not considered.

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